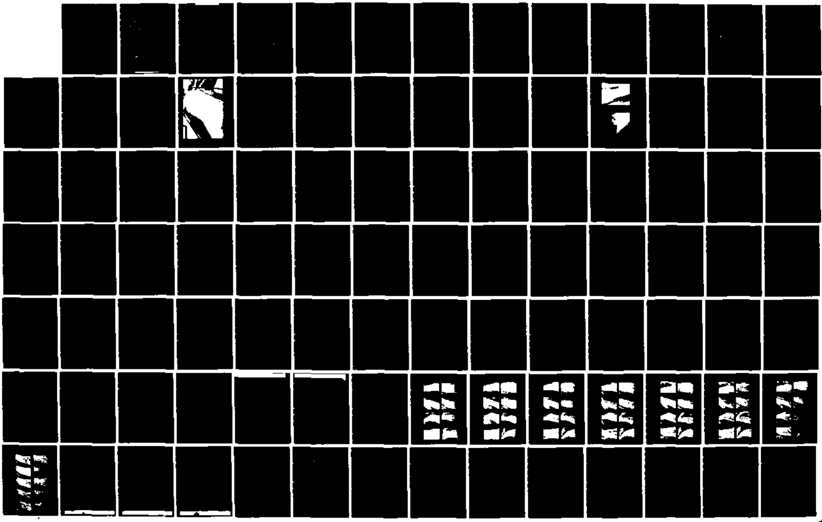
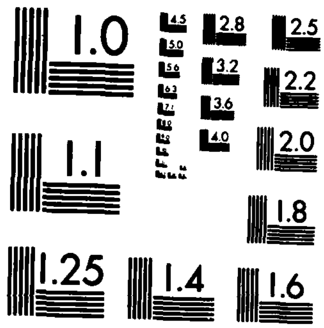
AD-A149 374 NAVIGATION CHANNEL IMPROVEMENT COLUMBIA RIVER OREGON AND WASHINGTON - LON..(U) ARMY ENGINEER DIV NORTH PACIFIC BONNEVILLE OR DIV HYDRAULIC L.. SEP 84 1/3

UNCLASSIFIED TR-118-1 F/G 13/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

7

TECHNICAL REPORT NO. 118-1

HYDRAULIC MODEL INVESTIGATION

Navigation Channel Improvement, Columbia River, Oregon and Washington - Longview to Kalama Reach, River Miles 64 to 78

SPONSORED BY
U. S. ARMY CORPS OF ENGINEERS
PORTLAND DISTRICT

CONDUCTED BY
DIVISION HYDRAULIC LABORATORY
U. S. ARMY CORPS OF ENGINEERS
NORTH PACIFIC DIVISION
BONNEVILLE, OREGON

SEPTEMBER 1984

US Army Corps
of Engineers
Seattle District

THIS DOCUMENT HAS BEEN APPROVED FOR PUBLIC RELEASE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report No. 118-1

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
NAVIGATION CHANNEL IMPROVEMENT, COLUMBIA RIVER, OREGON AND WASHINGTON, LONGVIEW TO KALAMA REACH RIVER MILES 64 TO 78
Hydraulic Model Investigation

5. TYPE OF REPORT & PERIOD COVERED
Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Engineer Division, North Pacific
Division Hydraulic Laboratory
Bonneville, Oregon 97008

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, Portland
P.O. Box 2946
Portland, Oregon 97204

12. REPORT DATE
September 1984

13. NUMBER OF PAGES
195

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Hydraulic Models
Columbia River
Navigation Channels
Movable-Bed Studies
Channel Scour and Fill

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A distorted scale (1:100 V, 1:300 H) movable-bed hydraulic model was used to evaluate 20 separate channel improvement designs in the Columbia River navigation channel between RM's 64 to 78. Descriptions of the tests and data relative to resulting channel scour and fill conditions are presented in the report.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

PREFACE

Model investigation of channel improvements in the Columbia River was requested by the U.S. Army Engineer District, Portland (NPP), in letters to the U.S. Army Engineer Division, North Pacific (NPD), dated 19 February and 4 November 1963. Authorizations to perform the overall study were granted on 4 April 1963 and 4 March 1964 by the Office, Chief of Engineers (OCE). The authorizations designated that the Columbia River from River Mile (RM) 52 to 109 be studied using five separate movable-bed models. The models were to remain available for operation for an extended period as long as results would be beneficial for new construction on the river and for operation and maintenance activities. The model covering the reach from RM 64 to 78 is the subject of this report.

Tests were conducted on the reach between RM 64 and 78 during the period January 1965 to December 1972. The studies were conducted in the North Pacific Division Hydraulic Laboratory (NPDHL). A cooperative effort was developed with U.S. Army Engineer Waterways Experiment Station (WES) to achieve satisfactory verification of model performance. The model study was under the direct supervision of Messrs. H. P. Theus, Director, and A. J. Chanda, Chief of the Hydraulics Branch. The engineer in immediate charge was Mr. B. B. Bradfield. Much of the initial report material was also written and organized by Mr. Bradfield. This report was prepared by Northwest Hydraulic Consultants Incorporated, and the U.S. Army Engineer District, Seattle, and makes use of Mr. Bradfield's earlier work.

During the course of this investigation, personnel of OCE, NPD, and NPP visited the laboratory to observe model operation and discuss test results. Close liaison was maintained with NPP personnel, and as tests were completed the results were furnished to those concerned. In addition, the model was demonstrated to members of port authorities and chambers of commerce, congressmen, public officials, fishing and navigation interests, and various interested parties. Public demonstrations of the model were held on 25 October 1966, 16 November 1966, and 1 May 1968. The model was demonstrated and current results of the study were discussed before the Committee on Channel Stabilization during the sixteenth meeting, 1-3 August 1967, and the twenty-second meeting, 21-23 July 1970.

CONTENTS

		Page
PREFACE		i
TABLE OF CONTENTS		iii
CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT		iv
PART I:	INTRODUCTION	1
	Description of Project	1
	Purpose of Study	2
	The Prototype	3
PART II:	THE MODEL	7
	Description	7
	Verification	8
	Scale Relationships	12
	Appurtenances	14
	Interpretation of Data	15
PART III:	IMPROVEMENT PLANS AND RESULTS	17
	Base Test, 35-ft-Deep by 500-ft-Wide Navigation Channel	18
	Plan 1	18
	Plan 2	20
	Plan 3	22
	Plan 4	25
	Plan 5	27
	Conclusions: Plans 1 through 5	29
	Plans 6 and 7	30
	Plan 8	31
	Conclusions: Plans 6 through 8	32
	Plan 9	33
	Plan 10	34
	Conclusions: Plans 9 and 10	36
	Plan 11	37
	Plan 12	41
	Plan 13	43
	Plan 14	48
	Plan 15	52
	Plans 16 through 20 (Slaughters Bar)	55
	Conclusions: Plans 16 through 20	62
PART IV:	SUMMARY	64
TABLES	1 and 2	
PHOTOGRAPHS	1 through 8	
PLATES	1 through 112	

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENTS

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles (statute)	1.6093	kilometers
feet per second	0.3048	meters per second
cubic feet per second	0.02832	cubic meters per second
cubic feet	0.02832	cubic meters
cubic yards	0.7646	cubic meters

NAVIGATION CHANNEL IMPROVEMENT

COLUMBIA RIVER, OREGON AND WASHINGTON

LONGVIEW TO KALAMA REACH

RIVER MILES 64 TO 78

Hydraulic Model Investigation

PART I: INTRODUCTION

Description of Project

1. The Columbia River, the largest river on the Pacific Coast, has drawn the attention of navigation interests since the discovery of its estuary in 1792. Beginning with the establishment of Astoria, Oregon, in 1811, the growth of numerous cities along the lower 110 miles* of its shores precipitated the need for a dependable channel for waterborne commerce. Originally, several bars within this lower reach of the Columbia had depths of only 12 to 15 ft at low water. The first project to establish a 20-ft depth was authorized by the Federal Government in 1878, and the first control works were installed the same year. With increasing demands for ocean commerce, the channel depth was subsequently increased to 25 ft by authorization of Congress in 1892. In 1912 the channel was further enlarged to a depth of 30 ft and width of 300 ft. Work was begun in 1930 to improve the channel to a depth of 35 ft and a width of 500 ft. Due to the increasing size of ships, the promise of greater use of the

---

* A table of factors for converting British units of measurement to metric units is presented on page v.

river, and the benefit to industrial expension, Congress approved the River and Harbor Act of 1962 which provides for a 40-ft navigation channel.

2. The dredging project authorized in 1962 provides for a channel 40 ft deep and 600 ft wide from near the river's mouth (RM 3)* to the mouth of the Willamette River (RM 101.5); then a channel 40 ft deep and 600 ft wide to the Burlington Northern railroad bridge at Vancouver, Washington (RM 105.5); and then a channel 35 ft deep and 500 ft wide to the Interstate 5 bridge which is the easterly end of the dredging project (RM 106.5). One turning basin 6,000 ft long by 1,200 ft wide and 40 ft deep is provided at Longview, Washington, and two turning basins are provided at Vancouver, Washington. The lower basin is 6,000 ft long by 1,200 ft wide and 40 ft deep, while the upper basin is 2,000 ft long by 800 ft wide and 35 ft deep. The project also includes 30- and 24-ft-deep auxiliary channels from the Columbia River channel to Mount St. Helens (RM 87) and Rainier, Oregon, (RM 68), respectively. Side channels are located at Cathlamet and Longview.

Purpose of Study

3. The general purpose of this study was to provide information relative to the effect of the proposed enlargement of the existing 35- by 500-ft navigation channel to 40 by 600 ft along

---

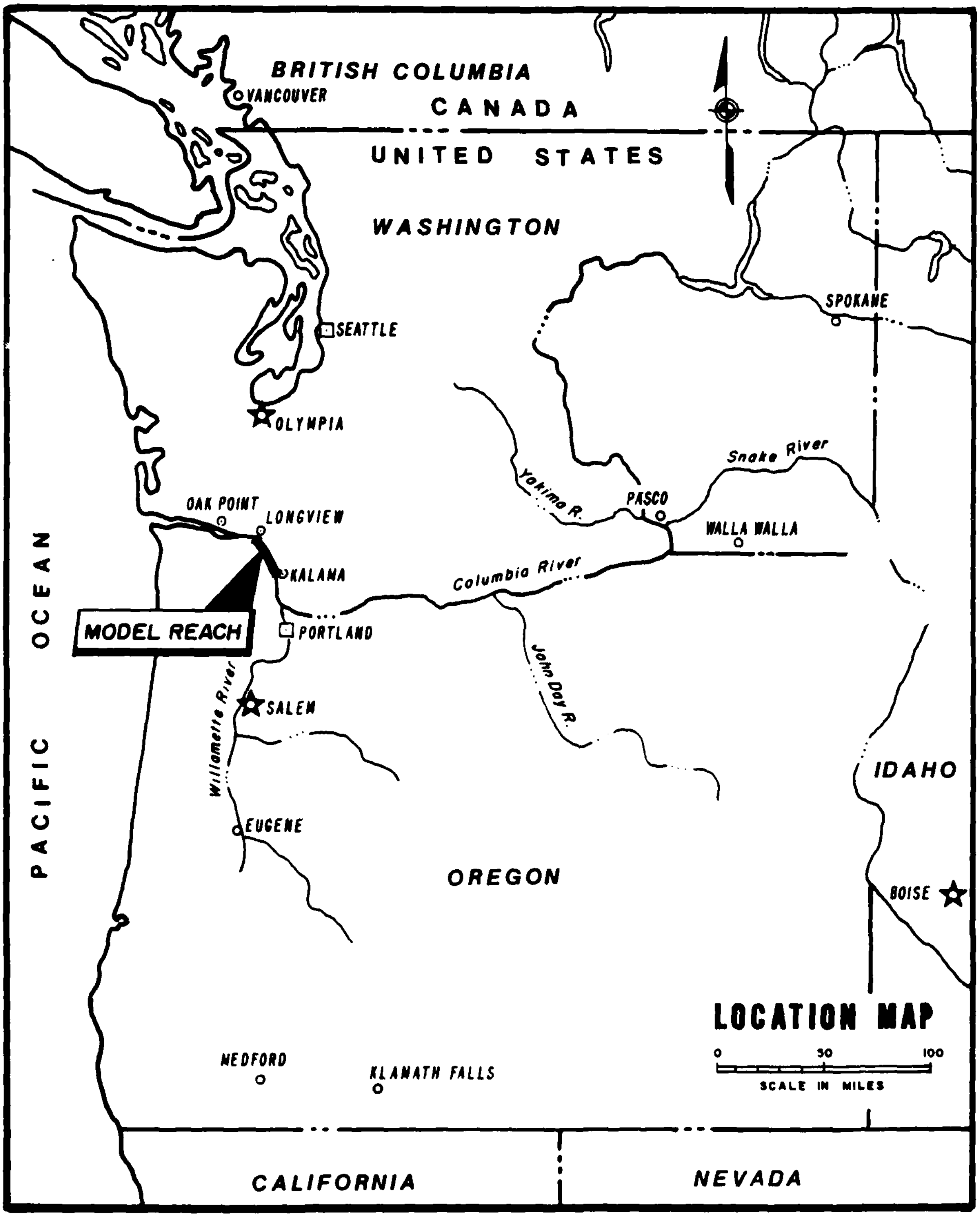
* RM 3 and all mileage cited henceforth are in RM measured from a point inline with the out end of the jetties at the mouth of the Columbia.

a 14-mile reach--RM 64 to 78. The effect and efficiency of proposed plans for control structures, navigation channel alignment, and location of dredge disposal areas were to be studied in order to determine the optimum plan for reducing initial and maintenance dredging.

The Prototype

4. The Columbia River has its origin in Lake Columbia, British Columbia, Canada, and follows a 1,210-mile indirect course in a generally southwesterly direction to the sea. The quarter-million square-mile drainage basin of the river encompasses the rugged, mountainous region of the Pacific Northwest--covering large portions of the States of Washington, Oregon, and Idaho--and extends into British Columbia. The drainage basin also includes small portions of northern Nevada and Utah and the western parts of Wyoming and Montana. The total fall of the river from the source to the sea is about 2,640 ft. In the final 110 miles from Vancouver, Washington, to the ocean (which includes the reach concerned with herein), the gradient sharply decreases with a fall of only about 5.5 ft in this distance at low water datum. Figure 1 shows the general site location and the river reach discussed in this study.

5. Within the reach of the Columbia involving the 40-ft channel project, there are 26 bars or problem areas which require annual maintenance dredging. Four of these bars are investigated in this study as follows: Kalama (RM 73.8 to 77.1); Upper Dobelbower (RM 70.0 to 72.1); Lower Dobelbower (RM 67.2 to 70.0);



BRITISH COLUMBIA
VANCOUVER
CANADA
UNITED STATES
WASHINGTON
SEATTLE
SPOKANE
OLYMPIA
Yakima R.
Snake River
PASCO
OAK POINT
LONGVIEW
WALLA WALLA
KALAMA
Columbia River
MODEL REACH
PORTLAND
John Day R.
Willamette River
SALEM
PACIFIC OCEAN
IDAHO
EUGENE
OREGON
BOISE
LOCATION MAP
0
50
100
SCALE IN MILES
MEDFORD
KLAMATH FALLS
CALIFORNIA
NEVADA

Figure 1

and Slaughters (RM 63.2 to 67.2). At the time of project authorization, the reach from RM 64 to 78 contained 25 pile dikes (located as shown on plate 1) totaling approximately 32,400 ft in length. These permeable groins helped to control the channel regime by stabilizing bank lines and dredge disposal areas and by maintaining the desired cross sectional dimensions of the river channel. Three active deepwater ports--Longview, Washington (RM 66); Rainier, Oregon (RM 67); and Kalama, Washington (RM 75)--are located in the reach of the lower Columbia River covered by this study. Two tributaries--the Kalama River and the Cowlitz River--flow into the Columbia in the study reach and provide additional avenues of waterborne commerce. A 28- to 30-ft-deep and 250- to 300-ft-wide auxillary navigation channel, parallel to the main channel, is maintained from RM 63.25 to 65.0.

6. The annual hydrograph for the lower Columbia River has two freshets. The major floods occur during the months of May, June, and July as a result of snowmelt. The secondary floods occur during the months of December and January and are due to winter rains in the Willamette valley. Maximum freshwater discharge has been estimated at 1,240,000 cfs, and the average maximum mean daily discharge is approximately 600,000 cfs for the reach of the Columbia discussed in this report.

7. The tidal effect on the lower Columbia River extends upstream as far as 141 miles during periods of low river discharge, and reversals of flow extend as far as 90 miles upstream. The diurnal tidal range (from mean higher high water to mean

lower low water) at the mouth of the river is 8.3 ft; at RM 52, 5.5 ft; and at RM 78, 3.5 ft. Near RM 52, average bottom velocities at a river discharge of 550,000 cfs vary from 4.4 to 1.8 fps for low and high tide, respectively. No saltwater density currents occur in the section of the river contained in the model.

8. The bed of the lower Columbia River consists primarily of clean sand and silt. The banks are of fairly firm clay except for rock in some reaches and are relatively stable. The Columbia River is not a heavy silt-carrying stream. Total movement of both suspended and bedload materials was estimated (1963) to range from 11.5 to 15 million cu yds per annum*. It has been estimated that about 3.5 million cu yds of the bedload result from the use of constriction works alone*.

---

* Robert E. Hickson, "Columbia River Stabilization and Improvement for Navigation" Symposium on Channel Stabilization Problems, Technical Report No. 1, Volume 3, Committee on Channel Stabilization, Corps of Engineers, U.S. Army, June 1965.

PART II: THE MODEL

Description

9. A combined fixed- and movable-bed model was used to assess and optimize dredging requirements for the proposed 40- by 600-ft navigation channnel. The layout of the model is shown on plate 1. The movable-bed portion of the model extended from RM 64.0 to 78.0 and generally included all the main river channel lower than elevation +5 CRD*. The main channel between RM 78.0 and 80.5, as well as the two secondary river channels (Goble and Carroll channels and the two tributaries Kalama and Cowlitz rivers), were of fixed-bed construction. Sufficient overbank topography (generally that from elevation +5 CRD to +25 CRD) was molded in concrete to permit flow to extend beyond the limits of the record flood. Sufficient overbank topography, molded in concrete, was included to permit flow through sloughs and secondary channels and to extend beyond the limits of the record flood. The steeper banks adjacent to the movable-bed sections were also molded in concrete.

10. Topographic and hydrographic survey sheets were developed specially for this study. Overbank topography was mapped from aerial photographs taken during the period from June to September 1963. Hydrographic data from Carroll and Goble channels and the Cowlitz and Kalama river mouths were obtained in August and November 1963. The starting geometry for the riverbed

---

* Columbia River datum (CRD) and mean sea level (MSL) intersect at approximately RM 70

was based on the 1961 predredge survey. Channel contours for this condition are shown on plates 2 and 3.

11. The movable-bed section of the model consisted of crushed coal having a specific gravity of 1.3 (saturated, surface dry) and a mean grain diameter of 1.8 mm. The particle size distribution of the coal used in the model is shown on plate 4. Templates, spaced approximately 3 ft apart (900-ft prototype), were suspended to the proper elevation from rails located along the concrete banks on each side of the movable-bed section. A portion of the model is shown in figure 2.

Verification

12. Model verification consisted of a trial-and-error procedure in which the following factors were varied: bed slope, discharge, run time, rate and manner of introducing bed material, and stage at model gage 25A. The verification hydrographs used for all model tests are shown on plate 5. Observations of model bedload movement, surveys of model bed configurations, and water surface profiles assisted in the verification. Stages less than 4.9 ft (freshwater discharge of 170,000 cfs) were not reproduced because bed movement was insignificant at these lower stages. Dredging performed in the model during each hydrograph duplicated prototype dredging as closely as practicable. The location and quantity removed, time of removal, and disposition of spoil material along the channel banks were in accordance with prototype data shown on plates 6 through 11. The dredging periods are indicated on the verification hydrographs.

Figure 2. Portion of Longview to Kalama Reach moveable-bed model built at 1:300 horizontal and 1:100 vertical scale.

13. Tidal fluctuations were not reproduced in the model--instead, a fixed stage-discharge relationship was used in which the tidal effects through the model reach were averaged. Daily maximum and minimum water surface elevations obtained from automatic tide gage traces during the verification period of 1 Oct 1961 through 1 Mar 1964 were related to freshwater discharges for the same period. The following two tide gages were used: St. Helens, Oregon, RM 86; and Longview, Washington, RM 66. Figure A of plate 12 shows plots of the maximum, minimum, and mean stage-discharge relationships at these river gages with the elevation datum adjusted to mean sea level. The mean stage-discharge curves are plotted in figure B of plate 12 for use in estimating model stages; the stage at RM 70.8 (the location of model reference gage 25A) was determined by interpolation.

14. During the preliminary phase of the model verification, observations were made of the movement of bed material, stability of the crushed-coal banks, pile dike design, flow directions in the upstream end of model, and flow distribution between the main channel and the secondary channels with both fixed-stage and simulated hydrograph methods of operation. Observations of the movement of bed material indicated that the amount of fines in the model bed material was excessive, resulting in unnatural cohesion of the bed material. The grain size distribution of the bed material used in the model (plate 4) was therefore adjusted to better simulate prototype conditions. All riverbanks molded in crushed coal were unstable with model slopes steeper than 1V:1H (1V:3H prototype) and at lesser slopes in some areas.

These banks required stabilization with either 3/4-inch gravel or concrete. It was also necessary to stabilize some relatively flat areas subject to excessive or unnatural scour. The revised movable-bed limits are shown on plate 1.

15. Fixed-stage tests were made to determine the required permeability of model pile dikes under various discharges. Permeability was adjusted to simulate local prototype scour and shoal areas adjacent to the dikes. A center-to-center spacing of 3/8 inch, for vertical piles was satisfactory at all discharges. The piles were alternately placed on the upstream and downstream side of the stringers.

16. Preliminary testing indicated that upstream approach-flow conditions in the model did not satisfactorily simulate prototype conditions due to the absence of a meander bend in the model coverage. Various systems of baffling and deflecting the inflow were attempted but there was no effective arrangement for all river stages. A 43-ft-long fixed-bed extension to the model reproducing the 1961 hydrograph between RM 78.0 and 80.5 was finally used to simulate prototype approach conditions.

17. Final verification tests were made to evaluate the adequacy of the adjustments. Model water surface profiles obtained during final verification and corresponding prototype profiles for selected river discharges are shown on plate 13. Model scour and fill maps for the 2.5-yr verification hydrograph are shown on plates 14 and 15. The corresponding prototype maps are shown on plates 16 and 17.

18. In general, results of the final verification tests indicated good agreement between model and prototype. Although some discrepancy existed between model and prototype bed contours, the important shoaling or scouring trends were in close agreement. The largest discrepancy occurred in the vicinity of Coffin Rock (RM 72.2 to 73.1). Since this area is not in a problem area the discrepancy is not considered serious.

Scale Relationships

19. The models were built to model to prototype scale ratios of 1:300 horizontal (H) and 1:100 vertical (V). This produced a slope distortion of 3 to 1, providing a steeper gradient to facilitate movement of the crushed-coal bed material. Based upon the horizontal and vertical scales, the following scale relationships apply in the study: area equals 1:90,000 and volume equals 1:9,000,000. The time and discharge scales were determined empirically in verification of the bed movement in the model as these quantities do not scale according to Froudian laws of similarity. These scale relationships are discussed in paragraph 20.

20. The following relationships were determined from movable-bed model verifications tests:

a. Discharge: Initially, the model discharge scale was based upon that required to simulate prototype river stages in the model. The initial scale resulted in excessive movement at the high stage and insufficient movement at the low stage. Adjustments were made to the discharge scale during model verifi-

cation based on the relative movement of model bed material at various river stages and on the development of scour and fill patterns required to reproduce prototype conditions. The final relationship was a variable scale (plate 18).

b. Rate of bedload introduction: Prototype bedload discharge data through the model reach was not available; therefore, the rate and manner of introducing material at the upstream end of the movable-bed section were determined during the verification tests. Consideration was given to (1) the rate of material movement through the upstream end of the model, (2) local movement in the model necessary to produce the desired bed patterns, and (3) the amount of material reaching the model tailbay. Plate 19 shows the bedload introduction rates in relation to river stage.

c. Time: The time scale was originally set at 5 minutes of model time for 1 prototype day based on experience with similar models at other hydraulic laboratories. However, verification tests indicated that better agreement with prototype shoaling patterns was obtained with time scales of 3.5 minutes of model time for 1 prototype day (1:411).

d. Slope: In addition to the geometric slope distortion of 3 provided by the model scales, the slope of the movable-bed portion of the models was steepened during model verification to 0.000300. This slope increase was required to provide the tractive forces necessary for acceptable simulation of prototype bed changes.

e. Stage: The river stage at gage 25A was determined from prototype data described in paragraph 13 and shown on plate 12.

During verification tests, however, the datum was lowered 0.5 ft (0.005 ft in the model) to further facilitate movement of the bed material.

f. Other scale relationships: Other scale relationships relevant to the model are as follows:

Dimensions	Relationship
Surface Area	1:90,000
Cross Section Area	1:30,000
Volume	1:9,000,000

Appurtenances

21. Water was supplied to the models from a closed circulating system. Model discharges were measured by calibrated bell-mouth orifices located in the supply line. Inflows from the tributaries of the Kalama and Cowlitz Rivers were measured by 60-degree V-notch weirs. Point gages were used for water surface measurements, and stage at the approximate center of the model (gage 25A, RM 70.8) was controlled by an adjustable rectangular weir in the tailbay. Velocities in the model were measured with a midget Ott C-1 current meter.

22. Folded strips of window screen were used to simulate the roughness of brush and tree growth along the banks of the channels. Shipping docks simulated in the model were constructed of hardware cloth to produce the roughness of dock piling. The permeable pile dikes were constructed of No. 9 galvanized wire,

and the vertical members were spaced to produce the required permeability in the model. A dolphin was placed on the riverward end of each dike simulating two three-pile clusters battered both upstream and downstream. A rock protection blanket was simulated at the base of each pile dike. Figures 3 and 4 show some of these appurtenances. The sounding apparatus used to survey the movable bed consisted of a vertically graduated rod which was referenced to a portable horizontally graduated rail mounted on the template rails. The sounding rod was calibrated in 1-ft units (prototype) and had a swivel foot on the bottom which rested on but would not penetrate the coal bed.

Interpretation of Data

23. In interpreting and evaluating the model test results, the shoaling quantities may be used quantitatively to compare improvement plans in the model but cannot be transferred in a strictly quantitative manner to the prototype river channel. Shoaling data in the tabulations and graphs are presented in cubic yards for convenience, but in applying these quantities to the prototype, consideration must be given to the degree of verification obtained in the model. The time scale developed during the verification period was used in reproducing the test hydrograph, but it is not necessarily an accurate indication of the time required for model developments to occur in the prototype under similar conditions.

Figure 3. Section of Longview to Kalama reach model showing simulated loading dock, brush and tree growth, and river bank roughness.

Figure 4. Simulated pile dike.

PART III: IMPROVEMENT PLANS AND RESULTS

24. A total of 20 improvement plans and one base test were modeled in the Longview to Kalama reach. The geometry simulated in the base test consisted of the prototype 1961 predredge condition with the existing 35-ft-deep by 500-ft-wide navigation channel alignment and existing corrective works. This base test was necessary to check verification, to determine if a reasonably stable bed would develop in the model, and to serve as a basis for evaluating the initial improvement plan (Plan 1) which consisted of a proposed 40-ft by 600-ft navigation channel with existing corrective works. Plan 1 then provided a basis for comparing the effect of various corrective works on the maintenance dredging requirements. The alignment of both the existing 35-ft-deep channel and the Plan 1 channel are shown on plates 20 and 21. The various corrective works were evaluated sequentially in improvement Plans 2 through 20. In all plans the navigation channel was dredged 5 ft deeper (unless otherwise stated) than the design depth which is the normal procedure followed in dredging of the prototype channel.

25. The 1962 water year hydrograph (plate 5) hereafter referred to as "the hydrograph" was simulated in the base test as well as all improvement plan tests. The hydrograph was repeated three times to produce approximate stability of the channel regime, and soundings were then made of the movable-bed portion of the model. With some plans tested the model bed did not reach a stabilized condition after testing with three hydrographs; therefore, the hydrograph was repeated six to nine times for

those plans. For this testing, the movable bed was surveyed after every three repetitions of the hydrograph. The stage-discharge relationship, time scale, rate and manner of introducing bed material, slope correction, and stage adjustment developed during the verification of the model were used for all tests.

Base Test, 35-ft-Deep by 500-ft-Wide Navigation Channel

26. The scour and fill* existing in the model following three successive hydrograph simulations are shown on plates 22 and 23. Total shoaling was 2.2 million cu yds, and the distribution of shoaling on each bar is given on plates 24 through 27. Shoaling depths up to 5 ft generally existed through the navigation channel between RM 66 and 70.5 and upstream from RM 74.5 and shoaling in excess of 5 ft existed in the vicinity of RM 69.2 to 70.5. Photograph 1 shows the surface flow patterns in the model with a simulated fresh-water discharge of 338,000 cfs.

Plan 1

Description

27. Plan 1 consisted of the enlarged 45-ft-deep (40 ft plus 5 ft of overdepth) by 600-ft-wide navigation channel molded in the model bed. The channel alignment was designed with a minimum number of bends and generally followed the deepest water. This alignment was similar to that of the existing 35-ft-deep channel except in the Kalama and Longview, Washington, areas. Near RM 77

---

* Scour and fill patterns were obtained by subtracting the initial from the final channel contours. Fill exceeding 5 ft in the navigation channel indicates areas where shoaling reduced channel depths to less than that required to provide minimum navigation depth.

the Plan 1 channel was shifted about 600 ft south to decrease curvature; near RM 65.5 it was shifted 500 ft south for the same reason. This latter change would also improve the approach to the 1200-ft-wide by 1-mile-long turning basin located at Longview, Washington (RM 66 to 67). The purposes of this test were to determine general shoaling conditions that would occur with the larger channel without additional corrective works and to provide a basis for comparison of subsequent improvement plans.

Results

28. The scour and fill after three hydrographs are shown on plates 28 and 29. The red cross-hatched areas on the drawings indicate areas where shoaling reduced the channel depth to less than 40 feet. The shoaling distribution for Plan 1 and the base test for the four bars situated in the modeled reach are shown graphically on plates 24 through 27. Table 1 summarizes the Plan 1 and base test shoaling quantities for Kalama, Upper Dobelbower, Lower Dobelbower and Slaughters bars (Plans 2 through 20 are also included on the table for subsequent comparative purposes). Photograph 2 shows the surface flow patterns during the test with a simulated freshwater discharge of 338,000 cfs.

29. Shoaling in the enlarged channel--totaling 3.4 million cu yds--was approximately 60 percent greater than that which occurred with the 35-ft channel. Overall shoaling in the Kalama bar reach with the Plan 1 channel increased about 160 percent while shoaling in the Upper Dobelbower bar reach increased about

80 percent. Shoaling increases on Lower Dobelbower and Slaughters bars were less than 10 percent each. Distribution of shoaled material was similar for the two channels on the Dobelbower bars but differed appreciably on the Kalama and Slaughters bars. On Kalama bar, shoaling increased with the Plan 1 configuration between RM 76.7 and 77.5 where the navigation channel was shifted to the south. Shoaling in the vicinity of RM 75.2 was less than that which occurred with the 35-ft channel base test. On Slaughters bar, the heaviest shoaling occurred at the upstream end of the turning basin (RM 67) where the cross sectional area was considerably increased by the 40-ft channel. As a result, a much smaller portion of the total shoaling occurred near RM 65.

Plan 2

Description

30. Plan 2 retained all features of Plan 1 and incorporated the dikes and disposal areas shown on plates 30 and 31. A total of 4,100 linear ft of pile dikes was added--600 ft on Kalama bar, 300 ft on Lower Dobelbower bar, and 3,200 ft on Slaughters bar. For the Kalama bar area, two 300-ft-long pile dikes were added on the north shore of Sandy Island, and disposal areas were added at the entrance to Goble channel on the Washington shore opposite the Goble channel entrance and on the downstream end of Sandy Island. On the Dobelbower bars, the pile dike on Howards Island upstream from the Cowlitz River mouth was extended 300 ft. Disposal areas were added on the Washington shore along Cotton-

wood and Howard Islands and on the Oregon shore near the upstream end of the Dobelbower bars. On Slaughters bar a disposal island and five stabilizing dikes were placed on the south side of the turning basin at Longview. Disposal areas were added on the Oregon shore downstream from the Longview bridge.

Results

31. Shoaling distribution patterns in the navigation channel after three hydrographs are shown graphically on plates 32 through 35. The shoaling distribution patterns indicated on the plates for Plan 2 and all subsequent plans are presented in terms of percent of total Plan 1 shoaling versus RM.

32. On the Kalama bar, Plan 2 was effective in reducing shoaling 44 percent throughout the reach, with the greatest reduction occurring upstream of the Sandy slough/Goble channel bifurcation. The reduction was due largely to the higher velocities produced by the constriction of the main channel and entrance to Goble channel (RM 75.4 to 77.5) resulting from placement of dredge disposal. The proposed pile dikes did not affect shoaling but did serve to stabilize the adjacent dredge spoil.

33. For the Upper and Lower Dobelbower bars, the disposal areas along the right bank and dike extension were effective in reducing shoaling 43 and 28 percent, respectively. Particular improvement was noted in the general vicinity of RM 71.6, RM 70 to 71.3, RM 69.9, and RM 67.6 to 68.4.

34. On Slaughters bar the disposal island reduced shoaling 47 percent in the turning basin and navigation channel upstream

from RM 66.2. However, a considerable amount of material was deposited at the downstream end of the turning basin between RM 64 and 66, and scour occurred along the right toe of the disposal island as a result of the large constriction from the disposal island.

35. Although Plan 2 reduced overall shoaling by approximately 37 percent, the plan was not considered totally successful as the shoaling on Kalama bar was still quite large (814,000 cu yds) and further reduction was desired. The scour occurring along the right toe of the disposal island between RM 66 and 67 extended up to 15 ft below the toe of the fill and was considered excessive.

Plan 3

Description

36. The Plan 3 scheme included corrective works for Kalama bar in an attempt to further reduce the shoaling on that bar. To aid in selecting the most effective corrective works for this bar, a series of five fixed-stage tests was conducted. The five schemes tested were as follows:

a. A 300-ft extension to dikes 76.86 and 77.26.

b. A 300-ft rock groin extension to dikes 76.86 and 77.26.

c. A 300-ft rock groin extension to dike 77.26.

d. A 300-ft rock groin extension to dike 77.26; a 300-ft extension to pile dike 76.86; a 600-ft extension to pile dike 76.58; and a 400-ft dike added at 75.27.

e. A 300-ft rock groin extension to dike 77.26; 300-ft extensions to dikes 76.86 and 76.58; and a 600-ft dike at 75.27.

In the above tests, the 300-ft-long pile dikes 75.84 and 75.50 and all disposal areas were retained from Plan 2. Scheme "e" gave the most satisfactory results for the Kalama bar and was incorporated in Plan 3 as shown on plates 36 and 37.

37. On the Upper and Lower Dobelbower bars, all dredge disposal areas were retained from Plan 2, as well as the 300-ft extension to dike 68.35. In addition, four submerged pile dikes (70.08, 70.56, 70.96, and 71.34) were placed on the Oregon side of the channel. The left ends of these dikes were placed at the minus 5-ft contour line, and each dike extended riverward to a point 1,800 ft from the right-bank dike line. The locations were staggered with respect to the existing dikes on the right shore. On Slaughters bar the disposal island near RM 66 was reduced in length from that of Plan 2, with the upstream portion eliminated and the downstream end extended a short distance beyond the left bridge pier. The revised island was located between RM 65.9 and 66.6 and accommodated 3 million cu yds of dredge spoil. The five stabilizing pile dikes for the disposal island were the same as those in Plan 2 except that the four upstream dikes were extended to within 200 ft of the navigation channel. The Oregon shore disposal area from RM 64 to 66 remained the same as that in Plan 2.

Results

38. The scour and fill patterns which existed after three hydrographs are shown on plates 38 and 39. Shoaling distribution is shown graphically on plates 32 through 35. Surface flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 3. Overall shoaling in the navigation channel was 43 percent less than that which occurred with Plan 1.

39. Channel shoaling on the Kalama bar with Plan 3 was reduced 52 percent from Plan 1 which was a slight improvement over Plan 2. The greatest improvement occurred in the vicinity of RM 75.2 and was attributed to the addition of dike 75.27 on the Washington side of the channel. The dike extensions along the Oregon shore upstream of Goble channel produced a slight reduction in shoaling between RM 76.7 and 77.2, but a slight increase occurred immediately downstream--RM 75.9 to 76.7. Shoaling was heavier in the entrance to Goble channel left of the navigation channel.

40. Shoaling on the Upper Dobelbower bar was essentially unchanged from that which occurred with Plan 2. The four-dike system on the bar side of the river channel (RM 70.08, 70.56, 70.96, and 71.34) had little affect on channel shoaling in this reach. Scouring was more severe immediately downstream from the dike system, and as a result, more shoaling occurred in the Lower Dobelbower bar channel (RM 67.7 to 68.9). Plan 3 was less effective than Plan 2 in reducing shoaling in the navigation channel.

41. The overall shoaling on Slaughters bar was improved with Plan 3 showing a reduction of approximately 46 percent from Plan 1. A definite improvement resulted from the smaller disposal island and the center dike system. Scouring between the navigation channel and the dikes in the vicinity of RM 67 was less severe than in Plan 2 with a maximum scour depth of 3 feet along the toe of the disposal island. Shoaling in the downstream end of the turning basin was 23 percent less than that occurring with Plan 2. Deposition occurred further downstream and to the right of the navigation channel from RM 64.8 to 65.8. Shoaling in this area approached elevation -30 CRD but was not considered objectionable.

Plan 4

Description

42. Although previous tests indicated that the introduction of groins and pile dikes on Kalama bar were effective in reducing shoaling on the bar, deposition on Kalama bar still remained the largest of any bar. In an attempt to further reduce shoaling on Kalama bar, the navigation channel was realigned near RM 77 to an area previously exhibiting less shoaling. All proposed dikes and dike extensions previously installed in the Kalama bar reach were eliminated so that the channel realignment effects could be independently assessed. All disposal areas were the same as those in Plans 2 and 3 except for the area on the downstream end of Sandy Island. This disposal area was moved shoreward approximately 300 ft to prevent an undesirable increase in flow at the Kalama shipping docks on the opposite shore. On the Dobelbower

bars, five pile dikes were placed midway between the existing six dikes along the Cottonwood and Howard Island shores. The four offshore dikes of Plan 3 were eliminated, and the proposed 300-ft extension to dike 68.35 from Plans 2 and 3 was retained. On Slaughters bar the disposal island along with the five stabilizing dikes were retained from Plan 3, but an additional 400-ft leading dike was placed upstream of the system. Plates 40 and 41 show the corrective works included in Plan 4.

Results

43. Shoaling distribution patterns after three hydrographs are shown on plates 42 through 45. Shoaling in the navigation channel for the entire model reach was reduced 36 percent from Plan 1--a slightly smaller reduction than that occurring with Plans 2 and 3.

44. As a result of the channel realignment, Kalama bar shoaling decreased 25 percent from Plan 1. Further testing with the realigned channel was considered warranted since the maximum shoaling was shifted to an area lying outside the navigation channel; however, the 40-ft channel depth was not maintained between RM 76.8 and 77.5.

45. The shoaling in the Upper Dobelbower bar was reduced 55 percent from Plan 1, while Lower Dobelbower bar shoaling was reduced 48 percent. The shoaling reduction throughout this reach was an improvement over that occurring with Plans 2 and 3. Hence, the five proposed pile dikes along the right bank of the Dobelbower bars were effective in reducing shoaling.

46. On the Slaughters bar, the additional dike (67.20) reduced shoaling 31 percent from Plan 1 and was considered a beneficial addition to the midstream island and dike system even though shoaling was increased over that occurring with Plan 3. This increase over Plan 3 was attributed to additional bedload entering Slaughters bar due to more-effective upstream controls.

Plan 5

Description

47. On Kalama bar, the revised channel alignment and the revised disposal area on lower Sandy Island were retained from Plan 4. In addition, four corrective works were added as shown on plate 46. On the Oregon shore, a 900-ft pile dike (77.48) was added and pile dike 77.26 was extended 600 ft--both to within 200 ft of the navigation channel. A 300-ft-long rock groin with side slopes of 1V on 1.5H and a 10-ft-wide berm at elevation 0 CRD was added to the riverward end of pile dike 76.86. On the Washington shore, pile dike 75.27 was placed 600 ft riverward to within 200 ft of the navigation channel. On the Dobelbower bars, dike 70.57 was eliminated because the Plan 4 test indicated it was not beneficial. All other dikes and disposal areas on the Dobelbower and Slaughters bars were the same as those in Plan 4 (plates 46 and 47).

Results

48. Channel scour and fill after three hydrographs are shown on plates 46 and 47. Shoaling distribution patterns are shown on plates 42 through 45. Surface flow patterns during a

simulated freshwater discharge of 338,000 cfs are shown in photograph 4. Shoaling in the navigation channel for the entire reach was reduced 46 percent from Plan 1 and was an improvement over Plans 2, 3, and 4, respectively.

49. Shoaling in the navigation channel on Kalama bar was reduced 63 percent from Plan 1--the largest reduction with any plan previously tested--although channel depths were reduced to 35 ft between RM 77.2 and 77.8. The greatest reduction occurred near RM 77 opposite the 300-ft rock groin extension to dike 76.86. In combination with the change in channel alignment, the groin greatly improved material movement in this area. Compared to previous schemes, shoaling with Plan 5 was heavier in the entrance to Goble channel and in time would probably restrict flow through the channel. Dike 75.27 on the Washington shore was also beneficial in reducing shoaling in the immediate area of the dike.

50. Shoaling on Upper Lobelbower bar decreased 40 percent from Plan 1; however, shoaling increased over the previously tested plans. The shoaling distribution patterns were similar to those in Plan 4 except between RM 70 and 71. In this reach, deposition was much heavier than in Plan 4 and at some points exceeded that of Plan 1. This increased deposition was attributed to the increased quantity of material that was carried through the upstream section of Kalama bar. On Lower Dobelbower bar, a 38-percent improvement over Plan 1 occurred. The shoaling pattern generally followed that of Plan 4 with slightly higher peaks in the vicinity of RM 68.0 and 69.9. This test was 10

percent less effective than Plan 4, but this was again attributed to the fact that considerably more material was carried through Kalama bar than that occurring with Plan 4.

51. Slaughters bar had 24 percent less shoaling than the Plan 1 test. Shoaling through this reach was greater with Plan 5 than with any of the previously tested plans. Since the corrective works used on Slaughters bar in Plans 3, 4, and 5 were similar, the variation in deposition was attributed to the effects of control works on the upstream bars.

Conclusions: Plans 1 through 5

52. In evaluating test results of Plans 1 through 5, it is apparent that the four problem areas cannot be considered independently as each is influenced by conditions on the other bars. With any of the plans tested, dredging would be required to maintain the 40-ft deep channel through the entire modeled reach. When the 40-ft channel was installed in the model without additional corrective works (Plan 1), the dredged channel shoaled rapidly with deposition starting at the upstream end of the model and progressing downstream. The addition of the center dike system and island on Slaughters bar (Plans 2 through 5) caused varied backwater effects upstream on the Dobelbower bars. Although the rock groins tested in Plans 3 and 5 were quite effective in moving bed material, their initial construction cost is high and maintenance may be a problem, and they also present a navigation hazard. Plan 5 resulted in the greatest overall shoaling decrease of the plans tested to date. For this plan,

the greatest decrease occurred on Kalama bar in the vicinity of the rock groin at dike 76.86, but the fact that more material was carried through this section caused increased deposition in downstream problem areas.

Plans 6 and 7

Description

53. Plans 6 and 7 only considered changes to the Kalama bar reach pile dike arrangement (plate 48). Though effective in reducing shoaling, the rock groins would be costly to construct and maintain and would be hazardous to navigation; therefore, the 300-ft rock groin extension to dike 76.86 from Plan 5 was replaced by a 600-ft pile dike extension in Plan 6. The pile dike extension and the pile dike at RM 75.27 were both eliminated in Plan 7.

Results

54. Shoaling distribution following testing with three hydrographs with Plans 6 and 7 are shown on plate 49. Shoaling in the navigation channel on Kalama bar was reduced between 30 and 38 percent from Plan 1. For the realigned navigation channel, the 600 ft pile dike extension was not as effective as the 300-ft rock groin extension in reducing shoaling. The tests indicated that the pile dike at RM 75.27 decreased shoaling between RM 74.52 and 75.61.

Plan 8

Description

55. For Plan 8 (plates 50 and 51) tests were conducted for the entire model reach with particular emphasis on the Kalama and Slaughters bars. On Kalama bar all conditions were the same as Plan 7 except that the 600-ft extension to pile dike 76.86 was eliminated and the 600-ft pile dike 75.27 was reinstalled. Slaughters bar was left uncontrolled by removing the six mid-stream pile dikes and disposal island. Thus, the testing for Plan 8 served as a base test for shoaling resulting from increased bedload movement caused by control works on upstream bars and could be used as a base test for evaluating the effects of control works on Slaughters bar. All other aspects of Plan 8 were the same as those of Plan 5.

Results

56. Shoaling distribution after testing with three hydrographs is shown graphically on plates 49, 52, 53, and 54. Overall shoaling was reduced from Plan 1 by 23 percent. This plan was not as effective as the other plans because Slaughters bar was uncontrolled, resulting in a 49 percent increase in shoaling through the Slaughters bar reach over Plan 1. This indicated the high susceptibility of this reach to increased shoaling when deposition on upstream bars was reduced and emphasized the need for constrictive works to keep bed material in motion through the Slaughters bar reach.

57. Kalama bar had 40 percent less shoaling than Plan 1 compared with 63-, 38-, and 30-percent reductions for Plans 5, 6, and 7, respectively. The absence of an extension to dike 76.86 allowed more material to accumulate in the navigation channel between RM 76.3 and 76.6 but less between RM 75.0 and 76.1. Increased deposition occurred in the entrance to Goble channel outside of and to the left of the navigation channel. The 600-ft-long extension to dike 76.86 used in Plans 6 and 7 was too long and tended to concentrate the bedload movement along the navigation channel. On the other hand, elimination of the dike extension caused an increase in shoaling in the navigation channel adjacent to the dike and in the entrance to Goble channel.

58. On the Upper and Lower Dobelbower bars the shoaling was reduced with respect to Plan 1 by 37 and 48 percent, respectively. This was similar to the reductions observed on previous tests (Plans 4 and 5). Except for a slightly higher peak at RM 71.77, the shoaling distribution on the Dobelbower bars was similar to previous tests.

Conclusions: Plans 6 through 8

59. Tests of Plans 6, 7, and 8 point out the importance of a pile dike or other type of control on Kalama bar in the vicinity of RM 75.27. The tests also indicated that an extension to dike 76.86 would be beneficial but that the length should be somewhat less than the 600 ft tested in Plan 8. Plan 8 testing also indicated that the 600-ft dike 75.27, the 900-ft dike 77.48, and the 600-ft extension to dike 77.26 should be retained for

additional testing. Unless sufficiently controlled, Slaughters bar will be vulnerable to increased shoaling when upstream reaches are controlled and deposition reduced. The results of the Plan 8 study indicated the importance of controls in the vicinity of the turning basin on Slaughters bar, such as the dike/island arrangement of Plans 3 through 5 or a shore disposal with similar cross sectional constriction. With all three plans shoaling which existed in the navigation channel would necessitate dredging to maintain the 40-foot channel depth.

Plan 9

Description

60. The test configuration for Plan 9 was the same as Plan 8 with the modifications noted on plates 55 and 56. On Kalama bar the 500-ft extension to dike 77.26 was reduced by 100 ft, dike 76.86 was extended 300 ft normal to the flow and its permeability was reduced by riprapping to elevation -10 CRD from the shore to within 200 ft of the riverward end of the extension, and a new 600-ft pile dike (77.02) was added midway between dikes 76.86 and 77.26. On the Dobelbower bars a 2,900-ft-long rock groin was added at RM 67.73 as shown on plate 55. The top of the groin was at elevation +20 CRD, and the side slopes were 1V to 1.5H. As in Plan 8, no control works were incorporated for Slaughters bar so that the effect of the rock groin on shoaling in the Longview turning basin could be determined.

Results

61. Shoaling distribution patterns after three hydrographs are shown on plates 57 through 60. Plan 9 reduced shoaling from

Plan 1 by 11 percent for the entire reach and was the least effective of all plans tested to this stage. The major reason for this plan's overall ineffectiveness was the large increase in shoaling (116 percent) observed on Slaughters bar due largely to the rock groin at RM 67.73. The proposed pile dike system upstream of the Goble channel bifurcation was effective in reducing navigation channel shoaling from the upstream end of the bar to RM 76.3. However, from that point to the downstream end of bar shoaling increased over Plan 8 indicating that the constriction on the downstream reach was not sufficient to maintain bedload movement.

Plan 10

Description

62. The test conditions (plates 55 and 56) were identical to those of Plan 9 except that (1) an 800-ft long dike was installed on Kalama bar as a spur of existing dike 75.46, (2) the Carroll channel entrance (RM 71.7) was closed by placing a 600-ft-wide earth dike to elevation +20 CRD across the narrow throat of the entrance and (3) the 2,900-ft rock groin proposed in Plan 9 was eliminated. Except for the disposal area present in Plans 2 to 9 on the Oregon shore, Slaughters bar was uncontrolled to determine the effect of the Carroll channel closure on both the turning basin and the reach in general.

Results

63. Shoaling distribution patterns after testing with three hydrographs are shown on plates 57 through 60. Scour and fill

conditions are shown on plates 61 and 62. The overall shoaling in the navigation channel for the entire model reach was 8 percent greater than Plan 1 due primarily to the large increase (152 percent) in shoaling on Slaughters bar.

64. On Kalama bar a 44 percent reduction in navigation channel shoaling from the base test occurred. This represented a slight improvement over Plan 9. Peak shoaling occurred at RM 76.3, with reductions from RM 76.8 to 77.3 and from RM 74.9 to 76.1. In comparing the results with Plan 9, a shoaling reduction was evident in the vicinity of pile dike 75.94; however, shoaling increased upstream from the dike indicating that the dike was too constrictive. Shoaling was also heavier in the entrance to Goble channel. Velocity measurements made at 15-ft depths adjacent to the right shore at RM 74.35 and 74.80 (areas already subjected to erosive flow conditions) indicated that pile dike 75.94 caused an approximately 10 percent increase in velocities over those existing with Plan 9.

65. The Upper and Lower Dobelbower bars had a 56-percent reduction and a 46-percent increase in shoaling relative to Plan 1, respectively. The increased flow in the main channel resulting from the closure of Carroll channel caused degradation to the left of the navigation channel on Upper Dobelbower bar. Shoaling along the bar side of the navigation channel from RM 71.8 downstream was less extensive than that which occurred with Plan 1. This was also true for Lower Dobelbower bar from RM 68.0 to 70 except for a peak in the vicinity of RM 69.5. On Lower Dobelbower bar, scouring increased considerably near the river-

ward ends of dikes 68.35 and 68.57 indicating increased impact of flow in this area; shoaling on the bar side of the river channel increased. Downstream from RM 68.0 (the exit of Carroll channel and Cowlitz River mouth) shoaling increased considerably, which accounted for approximately 44 of the 46-percent increase on Lower Dobelbower bar. Shoaling depths averaging 12 ft existed between RM 67.3 and 67.9 essentially covering the entire width of the navigation channel.

66. At Slaughters bar shoaling increased in the navigation channel by 152 percent from Plan 1 and was attributed to the closure of Carroll channel. As shown by the scour and fill drawing (plate 61), extremely heavy shoaling (up to 15 ft) occurred on the upstream end of the bar--both inside and outside the navigation channel limits. The shoaling distribution graph (plate 60) shows heavier deposition of material in the navigation channel generally throughout the bar with peak deposition occurring at the upstream end of the turning basin (RM 66.9).

Conclusions: Plans 9 and 10

67. As shown in table 1, shoaling in the navigation channel decreased 11 percent from that of Plan 1 in Plan 9 but increased 8 percent in Plan 10. The only bar to substantially benefit during the Plan 10 test was Upper Dobelbower bar, in the area adjacent to and immediately downstream from the Carroll channel bifurcation closure. In both Plans 9 and 10, Kalama bar exhibited slightly greater shoaling reductions than the previous three plans tested. The Oregon shore dike system upstream of

Goble channel bifurcation was beneficial in both Plans 9 and 10. The 800-ft extension to dike 75.46 included in Plan 10 is not recommended since it increased shoaling upstream in the navigation channel and in the entrance to Goble channel. Lower Dobelbower and Slaughters bars--the latter uncontrolled--had substantial increases in shoaling during both plans. Since Slaughters bar is located entirely downstream of the secondary channel modification, shoaling on the bar would have been reduced to approximately that of Plan 8 with additional testing (a 49-percent increase from the Plan 1 results). The rock groin 67.73 included in Plan 9 is not recommended since it increased shoaling in the Longview turning basin.

Plan 11

68. A series of preliminary tests was accomplished to determine the best arrangement or combination of improvements to be incorporated in subsequent plans. To conserve time and expense in these preliminary tests, an abbreviated 1962 hydrograph was used (repeated three times) in which only stages greater than 8 ft were simulated. In addition, for those stages simulated the duration of testing was reduced approximately 60 percent, which was considered sufficient to indicate shoaling and scouring trends resulting from the various proposed improvements. In addition to a base test, six major modifications were tested involving approximately 30 individual model changes. The major modifications consisted of the following:

a. Pile dike systems upstream of Goble channel bifurcation

b. Flow restrictions to Goble channel

c. Miscellaneous pile dikes on Kalama bar

d. Flow restrictions to Carroll channel

e. Shore restrictions on Slaughters bar

f. Midstream dike systems at Slaughters bar

Description

69. Plates 63 and 64 show the test configuration developed for Plan 11. On Kalama bar the navigation channel was realigned to a position 400 ft left of and parallel to the Plan 10 alignment in order to take advantage of a deeper section of the river on the upper portion of the bar and also to bring the channel closer to the Oregon shore dike system. The Oregon shore pile dike system upstream of Goble channel was the same as Plan 10 except for a 300-ft dike added at RM 76.42. The width of the entrance to Goble channel was reduced from 820 to 200 ft between dolphins of dike 76.34. This dike was extended 250 ft on the riverward side of the entrance and 620 ft in the segment adjacent to the Oregon shore. The shape of the disposal fill on both sides of the entrance was placed with the toes 100 ft from the entrance dolphins of dike 76.34. Pile dikes 75.40 and 75.78--200 ft long--were added on Sandy Island shore for bank stabilization. The 500-ft-long pile dike 75.27 was placed 400 ft from the toe of the navigation channel and 500 ft from the Washington shore in order to allow small boat passage around the shoreward end.

70. On the Dobelbower bars the earth dike that was placed across the entrance to Carroll channel for Plan 10 was removed.

A midstream dike system containing seven pile dikes was added on Slaughters bar as follows: 67.42 (450 ft long), 67.32 (850 ft long), 67.08 (800 ft long), 66.64 (750 ft long), 66.40 (750 ft long), and 66.16 (750 ft long). All other aspects of the plan were the same as those in Plan 10.

Results

71. With this plan, model stability was not reached after three hydrographs; therefore, the hydrograph was repeated six times to permit the river channel to reach a more stabilized condition. Soundings were taken after the third and sixth hydrographs, and the navigation channel was dredged to elevation -45 CRD prior to the fourth hydrograph. The resulting scour and fill after the sixth hydrographs are shown on plates 65 through 66, and shoaling distributions are shown on plates 67 through 70. Surface flow patterns for a simulated freshwater discharge of 338,000 cfs are shown in photograph 5. Shoaling in the navigation channel was reduced 35 percent from Plan 1.

72. Shoaling in the Kalama bar reach of the navigation channel was reduced from Plan 1 by 64 percent. Improvement occurred throughout the bar during the initial 3-yr test period except for a short reach from RM 76.3 to 76.7. The greatest reduction was in the vicinity of RM 77.0. During the second 3-yr test period, the greatest reduction occurred from RM 74.5 to 76.5, downstream of the Goble channel bifurcation. During this period of the test, virtually no additional shoaling occurred between RM 73 and 76.

73. Upper Dobelbower bar had a 58-percent increase in shoaling. The largest increase occurred in the vicinity of RM 71.58, located opposite the entrance to Carroll channel. Between RM 71.3 and 72.3, shoaling reduced the navigation channel depth to about 30 ft. This influx of material from Kalama bar was a result of higher velocities in the main channel following restriction of flow through Goble channel and the realignment of the navigation channel. The downstream portion of Upper Dobelbower bar (RM 70.0 to 71.4) had 8 percent less shoaling than that in Plan 1. Lower Dobelbower bar had 58 percent less shoaling in the navigation channel than that which occurred with Plan 1.

74. On Slaughters bar shoaling decreased 53 percent. Owing to its proximity to the navigation channel and turning basin, the midstream dike system was very effective in preventing bedload accumulation in the dredged area. Only a minor amount of shoaling was observed in the extreme upstream end of the turning basin. Shoaling was also evident along the right side of the navigation channel downstream from the Longview/Rainier bridge (RM 64.5 to 65.7). Two areas outside the limits of the navigation channel and turning basin shoaled extensively--one of these was to the left of the midstream pile dike systems and the other was adjacent to the log storage area to the right of the navigation channel (RM 64.5 to 66.0).

Plan 12

Description

75. Test conditions for Plan 12 (plates 71 and 72) were identical to Plan 11 except that on Kalama bar a 15-ft-wide riprap berm at elevation -10 CRD was added on the upstream (5-ft width) and downstream (10-ft width) sides of the 300-ft extension to pile dike 76.86 to reduce the permeability of the lower portion of the dike. The existing dike 71.87 on Upper Dobelbower bar was extended 500 ft normal to the flow with an additional 400-ft length added at RM 72.23. Both the extension and the new dike were riprapped to elevation -15 CRD to reduce permeability.

Results

76. The shoaling distribution after three hydrographs is shown graphically on plates 73 through 76. Table 5 shows that Plan 12 reduced overall shoaling 35 percent from Plan 1 which was similar to the reduction which occurred with Plan 11.

77. Riprapping the 300-ft extension to pile dike 76.86 did not produce a significant reduction in shoaling in the navigation channel on Kalama bar. Scour up to 8 ft occurred around the end of the dike extension, but deposition in the adjacent navigation channel was unchanged from that of Plan 11. Increased shoaling was apparent in the area between the entrance to Goble channel and the navigation channel immediately downstream from the rock dike extension. Deposition averaging approximately 10 ft also occurred in the navigation channel at RM 73.6 to 73.8.

78. Proposed dikes 71.87 and 72.23 on Upper Dobelbower bar reduced shoaling in the navigation channel from RM 71.6 to 72.1 by approximately 27 percent relative to Plan 11. Better movement of material and decreased deposition also occurred on Lower Dobelbower and Slaughters bars. Shoaling reductions from Plan 1 for these two bars were 63 and 23 percent, respectively.

79. On Kalama bar the four proposed pile dikes upstream of the Goble channel entrance in Plans 11 and 12 reduced shoaling considerably compared to the results of Plan 1. However, with the navigation channel realigned 400 ft to the left, shoaling from RM 76.3 to 76.8 was not reduced to the same extent as in Plans 9 and 10 (the same dike system with different channel alignment). Riprapping the proposed 300-ft extension to dike 76.86 in Plan 12 did not reduce deposition in the adjacent navigation channel. Restricting flow through Goble channel and realigning the navigation channel reduced shoaling in the navigation channel from RM 75.2 to 76.1, particularly during the second test period of Plan 11. The flow impact on the Washington shore in the vicinity of RM 74.35 and 74.83 was reduced by the realignment of the navigation channel across the bar. When tested in Plan 12, the proposed pile dikes 71.87 and 72.23 were effective in reducing shoaling on Upper Dobelbower bar in the vicinity of the Carroll channel bifurcation. On Slaughters bar the midstream pile dike system tested in Plans 11 and 12 was a very effective control for the turning basin area.

Plan 13

Description

80. Plan 13 was the same as Plan 12 except for the modifications noted on plates 77 and 78. On Kalama bar the navigation channel was realigned 400 ft nearer the right bank (the same alignment as in Plans 4 through 10). The constricted entrance to Goble channel was replaced by the design used in Plan 10 which had an 825-ft opening between dikes. The 300-ft extension to pile dike 76.86 was riprapped to elevation -10 CRD on the upstream, downstream, and riverward sides to provide a control somewhat similar to the rock groin of Plan 5 and was expected to be less hazardous to navigation. Due to the objections of local interests, pile dike 75.27 was omitted and in its place a disposal material fill training dike was added from RM 75.15 to 75.62. This 2,500-ft-long earth dike had 1V on 3H side slopes on the riverward side, 1V on 2H side slopes on the land side, and a 20-ft-wide berm at elevation +24 CRD. Four 235-ft-long stabilizing pile dikes (75.17, 75.27, 75.37, and 75.47) were placed normal to the riverward side of the earth training dike. These dikes were spaced 500 ft apart with cutoff elevation +8 CRD and had dolphins approximately 100 ft from the toe of the earth dike and 250 ft from the toe of the navigation channel. To determine the effect an expanded cross section would have on flow through the Kalama reach, a 500-ft-wide by 3,275-ft-long section to the left of the navigation channel between RM 74.22 and 74.84 was deepened to elevation -40 CRD.

81. On the Dobelbower bars, Carroll channel was closed at the entrance (RM 71.7). A similar closure was tested in Plan 10, but Plan 13 included an additional excavation in the main river channel downstream from the closure to reduce the excessive scour observed with the earlier plan. The 53-ft-deep by 800-ft-wide excavated area followed the navigation-channel alignment from RM 68.33 to 71.34 and had a 1,300-ft transition on each end to the 40- by 600-ft channel. Approximately 5 million cu yds of material in excess of that dredged for the 40- by 600-ft channel were removed from the river channel through this deepened section. This material was spoiled on Cottonwood and Howard Islands, to the right of the original 40-ft channel disposal, to top elevation +24CRD.

Results

82. This plan required testing with six hydrographs to attain a stabilized condition. The shoaling distributions after testing with six hydrographs are shown on plates 79 through 82. Overall shoaling was reduced 56 percent from Plan 1 and was a greater reduction than achieved in any previous test.

83. On Kalama bar, shoaling in the navigation channel was 43 percent less than that with Plan 1. This trend in shoaling reduction indicates that diking arrangements on upper Kalama bar employed in Plans 5 and 13 would initially lessen shoaling in the navigation channel, but as the channel approaches stabilization shoaling would slightly increase. Shoaling was heavier on the upstream portion of the bar than it was with Plan 12 indicating that the effectiveness of the proposed pile dike system upstream

of the Goble channel was reduced due to the realignment of the navigation channel. At the end of the third hydrograph, the riprapped pile dike extension to dike 76.86 was much less effective than the rock groin extension tested in Plan 5. Results from this plan and previous similar plans indicted that any extension to dike 76.86 along with the larger cross section of the 40-ft navigation channel resulted in the movement of considerably more bed material through Goble channel than was observed in the earlier tests and caused heavier than usual shoaling in the channel mouth to the left of the navigation channel. This shoaling was accentuated by the velocity reduction produced by existing dike 76.16 at the upstream end of Sandy Island. During the fourth through sixth hydrographs, material continued to accumulate in the entrance to Goble channel and more bed material moved down the main channel, resulting in increased shoaling in the navigation channel from RM 75.6 through 76.2.

84. On the downstream section of Kalama bar, an improvement was achieved opposite the training dike (RM 75.1 to 75.4) as evidenced by the shoaling distribution graph (plate 79). The river channel stabilized through this area during the early part of the test, and shoaling in the navigation channel was minor. Immediately downstream in the vicinity of the 40- by 500-ft dredged area, the river channel also stabilized during the first half of the test with little change taking place during the final three hydrographs. The increased cross sectional area resulting from the additional dredging and the training dike (RM 75) was

beneficial as it significantly reduced objectionable velocities along the right shore at RM 74.35.

85. Upper and Lower Dobelbower bars had 66 and 74 percent less shoaling respectively, than Plan 1. Most of the navigation channel shoaling occurred upstream and downstream of the 53- by 800-ft channel. This plan gave the greatest shoaling reduction on the Dobelbower bars of any plan studied.

86. Slaughters bar had a 56-percent shoaling reduction from Plan 1. The heaviest shoaling developed during the initial three hydrographs in the vicinity of RM 66.9 on the right side at the upstream end of the turning basin. However, after an additional three hydrographs, shoaling was greatly reduced and was approximately equal to the deposition at the downstream end of the turning basin. This initial deposition undoubtedly resulted from the scour of material from the Dobelbower bars during the first half of the test which did not occur during the second half. The center dike system concentrated the movement of bed material along the right side of the river channel downstream from the turning basin where it had a tendency to deposit in the vicinity of RM 65.3. This deposition could present a maintenance problem for a 250-ft-wide by 28-ft-deep auxiliary channel paralleling the log pond along the Washington shore (RM 64.0 to 66.0).

87. Plan 13 produced the best overall improvement in navigation channel shoaling of any plan tested to date, but most of this improvement resulted from the 13-ft overdepth provided in Upper and Lower Dobelbower bars where an additional 5 million cu

yds were dredged for the 53- by 800-ft channel. On upper Kalama bar, the navigation channel was aligned too far from its natural location along the left bank and too far from the proposed pile dikes upstream of RM 77.0 for the dike system to be effective. The navigation channel in the vicinity of RM 77 should be re-aligned to place it as close as possible to the proposed pile dikes along the left bank. In time, shoaling in the mouth of Gobel channel would result in increased shoaling in the navigation channel immediately downstream from the bifurcation. At the upstream end of Sandy Island, dike 76.16 is detrimental because it reduces velocities and causes increased deposition in the mouth of Goble channel and increases flow through the channel; this dike should be reduced in length to alleviate these undesirable conditions. The earth training dike and enlarged main channel on lower Kalama bar appear quite effective in both reducing shoaling through this reach and helping to reduce the flow impact along the right bank in the vicinity of RM 74.3. On the Dobelbower bars the 53- by 800-ft channel appears adequate to carry the increased flow normally carried by Carroll channel, but the right bank in the vicinity of RM 68.5 shows indications of increased attack and may require additional stabilization. The center dike system on Slaughters bar is effective through this reach, but shoaling in a secondary channel in the vicinity of RM 65.3 may present a problem.

Plan 14

Description

88. Test conditions for Plan 14 are shown on plates 83 and 84. Objections by local interests to the Plan 13 pile dike system on Kalama bar upstream of Goble channel necessitated the study of a less extensive dike system in Plan 14. Four dikes--77.48, 77.26, 77.02, and 76.86--were initially reduced in length by 500, 350, 200, and 200 ft, respectively and later (prior to the seventh hydrograph) reduced to 100, 200, 200 and 100 ft, respectively. The disposal area behind this dike system was extended riverward to place the toe of the fill 150 ft shoreward from the riverward ends of the dikes, thus reducing the cross sectional area of the river channel by approximately 5 percent. Downstream from the Goble channel bifurcation, the length of existing pile dike 76.16, was reduced 300 ft--leaving only a 340-ft section projecting into the river.

89. The navigation channel was realigned on upper Kalama bar to place it as close as possible to the shortened dike system. In this realignment the bend was approximately 1,700 ft downstream and 650 ft closer to the Oregon shore than it was in Plan 13. The disposal fill training dike adjacent to the Washington shore (RM 75.1 to 75.6) was retained from Plan 13 with minor revisions in location and shape. Along the riverward side of this training dike, four 300-ft-long stabilizing pile dikes were spaced 500 ft apart and normal to the training dike. The training dike berm was at elevation + 22 CRD, and the berm width was increased to 100 ft. Prior to the start of the test, a

dredged area to the left of the navigation channel--similar to that tested in Plan 13--was molded in the bed on lower Kalama bar from RM 74.25 to 74.85. The dredged material to be used as landfill away from the river totaled 1.3 million cu yds and was taken from a 500-ft-wide by 3,200-ft-long section deepened to elevations -45 and -50 CRD.

90. Test conditions on the Dobelbower bars were similar to those in Plan 13 except for minor revisions in the navigation channel alignment. The test configuration for Slaughters bar is shown on plate 83. Although the center dike system on Slaughters bar for Plan 13 was effective in reducing shoaling in the Longview turning basin, local interests strongly objected to this type of control. The center dike system was therefore omitted in favor of a disposal fill placed along the Rainier (left) shore and opposite the turning basin. Maximum width of the fill was 700 ft, the length was 2 mi (RM 65.4 to 67.4), and the top elevation was +22 CRD. Six pile dikes individually extending 150 ft beyond the toe of the fill were proposed to stabilize this disposal material. Existing dike 65.64, located near the downstream end of the disposal fill, was also extended 150 ft riverward.

Results

91. Plan 14 was tested with nine hydrographs, and soundings of the model bed were made following the third and sixth hydrographs prior to dredging the navigation channel to project depth. Shoaling distributions are shown on plates 85 through 88. A

shoaling reduction (from Plan 1) of approximately 60 percent was obtained with Plan 14. Scour and fill conditions after nine hydrographs are shown on plates 89 and 90. Surface flow patterns for a simulated freshwater discharge of 338,000 cfs are shown on photograph 6.

92. On Kalama bar the shoaling reduction in the navigation channel was 39 percent at the end of the ninth hydrograph. Heaviest shoaling occurred upstream of the Goble channel bifurcation where peak quantities deposited in the channel bend in the vicinity of RM 77. From this point downstream, shoaling gradually diminished to a negligible amount at RM 74.5. Following the seventh hydrograph, the effect on the bar of the dike revision is evident on the shoaling distribution graph (plate 85). An analysis of data from RM 74.5 to 77.5 indicated that 2.7 percent of the total 6.5-percent shoaling reduction during the final three hydrographs was attributable to the diking modifications made prior to the seventh hydrograph, and the remaining 3.8 percent was attributable to stabilization of the river channel. Velocity measurements indicated that the training dike and the increased cross sectional area of the river channel at RM 74.3 reduced velocities along the right shore by approximately 12 percent compared to that observed with previous plans (those prior to Plan 13) containing proposed pile dike 75.27.

93. On Upper and Lower Dobelbower bars, an improvement of approximately 65 percent from Plan 1 was obtained. Most of the shoaling in the navigation channel (above elevation -45 CRD) occurred upstream and downstream of the 53- by 800-ft channel (RM

68.1 to 71.5; plates 86 and 87). A buildup of material was evident on the left (bar) side of the 53- by 800-ft channel and a deepening occurred on the right side adjacent to the pile dikes. A heavy flow impact occurred along the right bank from RM 68.0 to 69.8, and the most severe scouring occurred along Howard Island in the vicinity of RM 68.4.

94. On Slaughters bar the channel restriction provided by the shore disposal of dredge spoil between RM 65.4 and 67.4 (opposite the turning basin) did not appear promising early in the test. After three hyrographs, heavy shoaling occurred along the right side of the turning basin and scouring occurred to the left of the navigation channel and adjacent to the disposal fill. By the end of the sixth hydrograph, however, a considerable improvement was noted as scouring action developed in the navigation channel and turning basin. By the end of the ninth hydrograph, a shoaling reduction was again evident. Peak shoaling during the second and third periods occurred at RM 65.9. The river channel from RM 65.5 to 67.0 (opposite the shore disposal fill) had not stabilized at the end of the test, since the average depth increased 0.7 ft during the final three hydrographs. A 78-percent shoaling reduction from Plan 1 was obtained. Downstream from the turning basin, shoaling in the navigation channel was minor. The river channel depths increased on the left side, but heavy shoaling occurred along the right shore. Depths less than elevation -28 CRD were evident along the right shore after the third hydrograph but decreased in this area during the remainder of the test. This deposition could present

a maintenance problem for a 250-ft-wide by 28-ft-deep auxiliary channel paralleling the log storage area on the Washington shore. The lateral distribution of velocities in the vicinity of the midstream dike system was obtained during the test, and the results are discussed and compared with other data in paragraph 102.

Plan 15

Description

95. The general features of Plan 15 (plates 91 and 92) were the same as those in the initial part of Plan 14 except that Carroll channel was reopened to allow flow and the 800-ft-wide by 53-ft-deep channel along the Dobelbower bars was eliminated.

96. On Kalama bar the pile dike arrangement upstream of the entrance to Goble channel was changed from that in the final Plan 14 to the less extensive system tested initially in Plan 14. Although more effective in reducing shoaling in the adjacent navigation channel, the more extensive system was eliminated due to objections by local fishing and towboat interests. In addition, pile dike 76.16 (downstream from Goble channel) was restored to its existing length of 640 ft.

97. The Upper Dobelbower reach reverted to the 600-ft-wide by 45-ft-deep navigation channel with the alignment employed in Plan 14. Since the closure of Carroll channel appeared to have little local support, further testing focused upon the effectiveness of the extensive shore fill opposite the turning basin on Slaughters bar (a feature retained from Plan 14) with normal flow

conditions through Carroll channel. Therefore, test conditions for Slaughters bar were unchanged from Plan 14.

Results

98. The scour and fill conditions after six hydrographs for Plan 15 are shown on plates 93 and 94. Shoaling distribution in the navigation channel is shown graphically on plates 95 through 98. Surface flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 7. An overall reduction in shoaling of approximately 33 percent occurred with Plan 15.

99. Shoaling in the navigation channel on Kalama bar was reduced 31 percent from Plan 1 after the sixth hydrograph. The shoaling distribution was similar to that of Plan 14 except that during the initial three hydrographs the deposition on the upstream section of the bar occurred slightly further downstream than during the same period in Plan 14. At the end of the test, peak shoaling occurred in the navigation channel bend at RM 77 but decreased significantly from that point to RM 76.3. Only negligible amounts deposited from RM 75.2 to the end of the bar. The training dike at RM 75.1 to 75.4 and the dredged area to the left of the navigation channel were effective in directing more flow along the bar side of the reach and in reducing shoaling on the downstream portion of the bar.

100. On Upper and Lower Dobelbower bars, shoaling reductions from the Plan 1 results were 28 percent and 58 percent, respectively. Peak shoaling occurred opposite the Carroll channel

bifurcation (RM 71.8) with lesser accumulations throughout the reach along the bar (left) side of the navigation channel. Extensive scouring occurred along the Howard and Cottonwood Island shores between RM 68.0 and 69.8 indicating that bank protection may be required through this reach.

101. On Slaughters bar the shoaling was greater than that with Plan 1 during the initial three hydrographs of the test, but by the end of the sixth hydrograph, a 25-percent reduction had occurred. Downstream from the turning basin, shoaling generally exceeded that of Plan 1 with a peak occurring in the transition from the basin to the navigation channel at RM 65.9. The shoaling increase between RM 64.6 and 65.1 was typical of those improvement plans with either the center-dike, dike-island, or shore-disposal type of control in the vicinity of the turning basin. Heavy shoaling also occurred to the right of the navigation channel (RM 64.5 to 65.8). In time, this disposition could present a maintenance problem for the 250-ft-wide by 28-ft-deep auxiliary channel paralleling the log storage area along the Washington shore.

102. A comparison of the changes in lateral distribution of velocities measured in the model on Slaughters bar for Plans 13, 14, and 15 is shown on plates 99 and 100. The data show the effects of the dike island (Plan 1) and the Oregon shore fill with (Plan 14) and without (Plan 15) closure of Carroll channel. Current meter measurements of velocities were made at uniform intervals across four cross sections--two between RM 66.22 and

66.87, one upstream of RM 67.37, and one downstream of RM 65.60. The velocity data were plotted in terms of percentage change from velocities obtained for the 35-ft channel base test conditions which were based upon the mean of velocities measured at two simulated discharges--338,000 and 450,000 cfs. Velocities were measured at 15-ft depths and were not necessarily a representation of the average in the vertical. In the cross sections upstream of and through the Longview turning basin, Plan 15 had lower velocities on the right side of the channel and higher velocities on the left side than did Plan 14. Of the three plans tested, Plan 13 generally resulted in the highest velocities along the right side adjacent to the Longview docks.

Plans 16 through 20 (Slaughters Bar)

103. Improvement Plans 16 through 20 were only concerned with modifications on Slaughters bar between RM 64.5 and 67.3. Plans 16 through 18 were a continuation of previous studies to determine the most effective and acceptable means of reducing shoaling in this reach by constricting the channel cross section, while Plans 19 and 20 provided the necessary base tests for comparison and analysis of Plans 16 through 18. The general features of the Oregon shore fill employed in Plans 16 and 18 were suggested by the Port of Portland during a public hearing regarding the 40-ft channel held in Rainier, Oregon, on 17 January 1969. Modifications to this shore fill in Plan 17 and the revised dredging procedure used in Plan 18 were the result of discussions subsequent to the hearing between representatives of the Port of Portland, NPP, and NPDHL. For all plans the upstream

reaches of the model--Kalama, Upper Dobelbower, and Lower Dobelbower bars--retained the features of Plan 15 (plates 91 and 92) including the navigation channel alignment, proposed pile dikes, shore disposal fills, and the training dike.

Description of Plans 19 and 20

104. Plans 19 and 20 (plate 101) were an extension of Plan 1 for Slaughters bar. In Plan 20 test conditions on the bar were essentially the same as those in Plan 1 with the 600-ft-wide by 45-ft-deep navigation channel and the turning basin (RM 66 to 67) molded in the riverbed. An additional feature in Plan 20 was the Oregon shore fill disposal area downstream from the Longview/Rainier bridge (RM 64 to 66). Plan 19 differed from Plan 20 only in construction and maintenance dredging depths. The navigation channel was initially dredged to elevation -45 CRD throughout the model, but the turning basin outside the 600-ft-wide navigation channel was only dredged to elevation -40 CRD. The navigation channel was dredged to elevation -45 CRD prior to the fourth and seventh hydrographs except in the vicinity of the turning basin (RM 65.7 to 67.5). The section near the turning basin was dredged to elevation -42 CRD, and the turning basin outside the navigation channel was dredged to elevation -35 CRD.

Results of Plan 20

105. The improvements developed in prior tests for the three upstream bars caused a higher initial rate of bedload transport into the Slaughters bar reach than occurred with Plan 1. In order to provide the additional time for the channel to

stabilize, Plan 20 was tested for three 3-yr hydrographs as opposed to only one 3-yr hydrograph in Plan 1. Prior to each 3-yr test period, the navigation channel throughout the model and the turning basin were dredged to elevation -45 CRD and the bed on Slaughters bar was sounded at the end of each period. Channel scour and fill are shown on plate 102 and shoaling distribution in the navigation channel is shown graphically on plate 103. Shoaling did not exceed 5 ft depth any place in the navigation channel. Surface and bottom flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 8.

106. Shoaling reduction curves for the turning basin and adjacent navigation channel (RM 65.7 to 67.3) and for the total portion of the bar contained in the model (RM 64.5 to 67.3) are shown on figures A and B of plate 104, respectively. For the turning basin and adjacent navigation channel (RM 65.7 to 67.3), the deposition under stabilized conditions was 29 percent less than the Plan 1 total (figure A). Since 14 percent of the total Plan 1 shoaling occurred outside RM 65.7 to 67.3, the effective Plan 20 reduction relative to total Plan 1 shoaling is 15 percent (29 minus 14 percent). The shoaling reduction from RM 64.5 to 67.3 under stabilized Plan 20 conditions was approximately 11 percent less than the Plan 1 total as shown by extrapolation on figure B of plate 104. The scour and fill drawings and shoaling graphs show that the heaviest shoaling occurred in the navigation channel at the upper end of the turning basin. Changes in the lateral distribution of velocity at RM 65.60 and 66.22 from that

which existed in the 35-ft channel base test are shown on plate 105.

Results of Plan 19

107. The shoaling distribution in the navigation channel and turning basin after three 3-yr hydrographs is shown on plate 106. Surface flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 9. The scour and fill patterns (plate 107) and the shoaling distribution show that most of the deposition occurred at the upstream end of the turning basin within the navigation channel limits. Only minor deposition occurred in the turning basin outside the navigation channel. During the initial three hydrographs, Plan 19 resulted in 13 percent more shoaling on Slaughters bar than Plan 1 as compared to a 99 percent increase which occurred with Plan 20. The shoaling reduction curve shown on figure B of plate 104 indicated that total deposition on the bar under stabilized conditions would be approximately 18 percent less than occurred with Plan 20. For the turning basin and the adjacent navigation channel (RM 65.7 to 67.3), the reduction was 21 percent. The mean velocity measured in the cross section at RM 66.22 (plate 108) was 6 percent higher than that of Plan 20 (plate 105), with most of the increase occurring adjacent to the shores. Little difference in velocities between Plans 19 and 20 was observed at RM 65.60.

Description of Plans 16, 17 and 18

108. The principal feature of Plans 16, 17 and 18 was fill placed on the Oregon shore from RM 65.6 to 66.4 as shown on plate

109. This fill projected into the river a maximum of 600 ft at RM 66.2 and was built to elevation +22 CRD. A relocated dock, to serve an adjoining property owner, was simulated off the riverward end of the fill at the maximum point of protrusion. Pile dike 65.64 (near the downstream limits of the fill) was extended 150 ft riverward. The Oregon shore disposal fill from RM 64.0 to 65.6 remained as in Plans 2 through 15. In Plan 17 only, a submerged fill was placed along the Oregon shore, upstream from the Plan 16 shore disposal fill. The top of this additional fill was established at elevation -12 CRD to provide sufficient depth of flow for shallow-draft navigation and log-rafting operations. The average width of the fill was 600 ft--providing a 7-percent reduction in the cross sectional area of the river channel along the upper reaches of the turning basin. The upstream end tapered into the Oregon shore between RM 67.0 and 67.4. Plan 18 only differed from Plan 16 in that the revised construction and maintenance dredging procedures used in Plan 19 were also used in Plan 18.

Results of Plan 16

109. The scour and fill existing after nine hydrographs are shown on plate 110. With this plan, shoaling did not exceed a depth of 5 ft in any portion of the channel. Surface flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 9. With regard to the Oregon shore fill constriction, plate 103 graphically shows the extent and location of the reduced shoaling for each of the three test periods. Downstream from the turning basin, shoaling increased between the

navigation channel and the log storage area. In time, this would increase the maintenance dredging of an auxiliary navigation channel paralleling the log storage area. There was also evidence of increased scour around the two Longview/Rainier bridge piers due to higher velocities produced by the constriction. An assessment of changes in lateral distribution of velocity at RM 66.22 (plate 105) indicated an increase in velocities of 10 percent along the right shore and 9 percent along the left shore. At RM 65.60, a 10-percent velocity increase was still apparent on the right side of the channel, but the velocity increase on the left was smaller. The Oregon shore fill displaced bottom flow lines along the left side of the river channel from 500 to 600 ft towards mid-channel at RM 66.22 and from 200 to 300 ft towards mid-channel at RM 65.60. This displacement gradually diminished from left to right across the channel to little or none along the right shore.

Results of Plan 17

110. As shown on the scour and fill drawing (plate 111), shoaling depths did not exceed 5 ft following testing with nine hydrographs. Surface flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 9. Increased scour occurred between the submerged fill and the turning basin and increased deposition downstream from the Longview/Rainier bridge between RM 64.5 and 65.5. Shoaling in the turning basin under stabilized conditions was 8 percent less than that of Plan 16 (figure A of plate 104), but the shoaling on the bar increased 3 percent (figure B of plate 104). As in Plan 16, increased

scour was evident around the bridge piers, and in time the increased shoaling adjacent to the log storage area in the vicinity of RM 65 would increase the maintenance dredging requirements of the auxiliary navigation channel as compared to Plan 1. Shoaling on the bar during the first three hydrographs was 78 percent higher than in Plan 1 and 17 percent higher than in Plan 16. The accumulation in the turning basin and adjacent navigation channel (RM 65.7 to 67.3) was the same in both plans--36 percent (figure A of plate 104). The shoaling reduction under stabilized conditions for this reach was approximately 27 percent less than Plan 20 and 21 percent less for the bar. The lateral distribution of velocity (plate 105) at RM 66.22 was similar to that of Plan 16 with the right shore velocities approximately 11 percent higher than in the 35-ft channel base test. At RM 65.60, velocities along the right shore were about 7 percent higher.

Results of Plan 18

111. As shown on plate 112, an area approximately 250 ft by 1,500 ft near RM 67 shoaled to a depth of about 7 ft after testing with nine hydrographs. The shoaling distribution in the navigation channel and turning basin is shown on plate 106. The shoaling reduction under stabilized conditions for the plan is shown on plate 104, and surface flow patterns during a simulated freshwater discharge of 338,000 cfs are shown in photograph 9. The shoaling distribution shows increased shoaling along the upper reaches of the turning basin and adjacent navigation channel during the initial three hydrographs. The constrictive effects of the shore fill and reduced dredging depths produced

initially a backwater effect upstream, resulting in decreased sediment transport through the reach. The 4th through 6th and 7th through 9th hydrograph periods, however, had 19 and 30 percent less shoaling, respectively, than occurred in this area with Plan 19. As in Plans 16 and 17, deposition was heavier downstream from the Longview/Rainier bridge and adjacent to the log storage area. Increased scour also occurred around the bridge piers, as in the two previous plans. For the turning basin and adjacent navigation channel (RM 65.7 to 67.3), the shoaling under stabilized conditions was approximately 28 percent less than Plan 19. For the bar the shoaling under stabilized conditions was approximately 31 percent less than Plan 19 (figure B of plate 104). The mean velocity across the section at RM 66.22 (plate 108) was 11 percent higher than occurred in the 35-ft channel base test; at RM 65.60 the increase in the mean velocity was 5 percent.

Conclusions: Plans 16 through 20

112. The most effective shoaling controls on Slaughters bar were the midstream island and pile dike system (Plans 2 through 5 and 11 through 13) followed by the Oregon shore fill and pile dike system (Plans 14 and 15); however, these were unacceptable to local interests on the river. The smaller shore fill system in Plans 16 and 18 is, perhaps, the best alternative from the standpoints of hydraulics and acceptance by local interests. In Plan 18 the combination of the fill and shallower dredging depths caused heavier deposition in the upper end of the turning basin

early in the test. As the backwater effect from the constriction was alleviated, the shoaling decreased and the effects of the improvements were noticeable. The Oregon shore fill that was tested in Plans 16 and 18 did not extend far enough upstream to provide the constrictive effect needed in the expanded cross section at the turning basin. Scouring around the Longview/Rainier bridge piers was intensified, and the constriction caused an increase in deposition downstream from the bridge adjacent to the log storage area. In Plan 19 the revised dredging procedure (when compared with the standard dredging procedure in Plan 1) resulted in a shoaling reduction of approximately 20 percent. The addition of the fill and dock structure (Plans 16 and 18) effected a 20- to 30-percent reduction depending on the dredging procedure used (Plan 20 or 19).

PART IV: SUMMARY

113. The results of the model testing program have been presented as a basis for comparison of the performance of certain proposed plans for navigation channel improvement on the Columbia River from RM 64 to 78. The model simulation of prototype velocity distribution, bedload transport, and scouring and shoaling tendencies was adequate to provide reliable information about the relative changes in these quantities from plan to plan. The test results are thus useful for the development of strategies for shoaling reduction and mitigation of any potentially undesirable impact upon the river system. However, given the nature of uncertainties in the model verification procedures--which are to some degree inherent in distorted-scale, movable-bed modeling techniques--the model results should not be construed to be accurate indicators of the absolute values of velocity, bedload transport rate, or shoaling volume which would occur in the prototype for the simulated flows.

114. Table 1 summarizes the shoaling quantities for each bar and for all bars combined. Plans 13 and 14 provided the greatest shoaling reductions (56 and 57 percent, respectively) of any of the plans tested; however, these two plans had the largest construction dredging requirements (table 2 lists the construction dredging requirements for all of the 20 improvement plans tested in the model), and portions of the plans were objectionable to local interests. While not the most effective of those tested, Plan 15 gives an indication of the maximum shoaling

reductions that can be achieved with controls which are acceptable to the many local interests along the river. The shoaling reduction for this plan is approximately 33 percent--approximately 25 percent less than either Plan 13 or 14. While the Oregon shore fill on Slaughters bar opposite the turning basin in Plan 15 was not as effective as the midstream controls of Plans 2 through 5 and 11 through 13--which were unacceptable to local interests--it was deemed the most practical and economical means to control the bar. Of the alternative shore fills tested at this location--Plans 16 through 18--Plan 16 would be recommended. However, since the control works for this plan were less extensive and located further downstream from the upper end of the turning basin than those in Plan 15, this plan was much less effective in reducing overall shoaling in the navigation channel.

TABLE 1

SUMMARY OF SHOALING QUANTITIES, 40- X 600-FT CHANNEL

PLANS 1 TO 20

Plan No.	Bars: Kalama Cu Yds	Bars: Kalama % Change From Plan 1	Bars: Upper Dobelbower Cu Yds	Bars: Upper Dobelbower % Change From Plan 1	Bars: Lower Dobelbower Cu Yds	Bars: Lower Dobelbower % Change From Plan 1	Bars: Slaughters Cu Yds	Bars: Slaughters % Change From Plan 1	Totals Cu Yds	Totals % Change From Plan 1
35-Ft Channel (Base Test)	559 800		420 500		521 000		660 000		2 161 400	
40-Ft Channel (Base Test) 1	1 452 500		748 600		563 400		705 800		3 470 300	
2	814 000	-44	423 400	-43	403 400	-28	528 800	-25	2 169 600	-37
3	689 800	-52	429 400	-42	456 600	-19	385 800	-46	1 961 600	-43
4	1 083 000	-25	340 300	-55	295 500	-48	488 400	-31	2 207 200	-36
5	535 900	-63	447 700	-40	347 300	-38	533 800	-24	1 864 700	-46
6	902 700	-38								
7	1 020 000	-30								
8	872 600	-40	470 800	-37	292 700	-48	1 052 700	+49	2 688 800	-23
9	852 100	-41	412 500	-45	304 800	-46	1 527 900	+116	3 097 300	-11
10	807 300	-44	331 400	-56	822 600	+46	1 781 500	+152	3 742 800	+ 8
11	837 300	-42	996 500	+33	312 800	-44	621 800	-12	2 768 400	-20
(4-6 yrs)	515 900	-64	1 181 000	+58	235 600	-58	334 800	-53	2 267 300	-35
12	891 600	-39	618 800	-17	207 800	-63	544 800	-23	2 263 000	-35
13	765 500	-47	129 100	-83	149 100	-74	470 600	-33	1 514 200	-56

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(4-6 yrs)	515 900	-64	1 181 000	+58	235 600	-58	334 800	-53	2 267 300	-35
12	891 600	-39	618 800	-17	207 800	-63	544 800	-23	2 263 000	-35
13	765 500	-47	129 100	-83	149 100	-74	470 600	-33	1 514 200	-56
(4-6 yrs)	824 500	-43	251 900	-66	145 500	-74	312 100	-56	1 534 000	-56
14	1 182 900	-19	190 900	-75	187 800	-67	823 500	+17	2 385 100	-31
(4-6 yrs)	983 100	-32	235 200	-69	178 200	-68	371 100	-47	1 767 600	-49
(7-9 yrs)	888 300*	-39	259 400	-65	181 500	-68	156 000	-78	1 485 200	-57
15	1 144 000	-21	571 500	-24	270 400	-52	768 900	+ 9	2 754 800	-21
(4-6 yrs)	1 004 500	-31	541 300	-28	236 900	-58	528 500	-25	2 311 200	-33
16							1 137 200	+61		
(4-6 yrs)							681 700	- 4		
(7-9 yrs)							503 500	-29		
17							1 258 000	+78		
(4-6 yrs)							772 700	+ 9		
(7-9 yrs)							554 400	-21		
18							826 000	+17		
(4-6 yrs)							469 100	-33		
(7-9 yrs)							309 600	-56		
19							800 900	+13		
(4-6 yrs)							605 800	-14		
(7-9 yrs)							520 000	-26		
20							1 405 700	+99		
(4-6 yrs)							889 700	+26		
(7-9 yrs)							683 900	- 3		

* Proposed pile dikes on Kalama Bar were revised prior to this part of test

NOTES: 1. Percentages are based on shoaling quantities in plan 1 (40-ft channel base test) with no corrective works.

2. Shoaling quantities are for the initial 3-year hydrographs except as indicated.

3. With the exception of plans 18 and 19, the navigation channel and Longview turning basin were dredged to 45-ft depth prior to the start of the tests and to the 4th and 7th hydrographs.

4. Tests 18 and 19 were begun with the navigation channel dredged to 45-ft depth, and the Longview turning basin to 40-ft depth. Prior to the 4th and 7th hydrographs, the channel was dredged only to 42-ft depth between miles 65.7 and 67.5, and the turning basin was maintained at 35-ft depth.

2

TABLE 2

CONSTRUCTION DREDGING REQUIREMENTS, 40- X 600-FT CHANNEL

PLANS 1 TO 20

<table>
<tr><th rowspan="2">Plan No.</th><th colspan="5">Construction Dredging Requirements in Cubic Yards</th></tr>
<tr><th>Kalama Bar</th><th>Upper Dobelbower Bar</th><th>Lower Dobelbower Bar</th><th>Slaughters Bar</th><th>Total</th></tr>
<tr><td>1
2
3</td><td>1,790,000</td><td rowspan="3">1,360,000</td><td rowspan="3">1,095,000</td><td rowspan="6">4,340,000</td><td>8,585,000</td></tr>
<tr><td>4
5
6
7
8
9
10</td><td>1,930,000</td><td>8,725,000</td></tr>
<tr><td>11
12</td><td>2,730,000</td><td>9,525,000</td></tr>
<tr><td>13</td><td>1,930,000[1]</td><td>4,090,000[2]</td><td rowspan="2">3,380,000</td><td>13,740,000</td></tr>
<tr><td>14</td><td rowspan="4">1,770,000[3]</td><td>4,190,000[2]</td><td>13,680,000</td></tr>
<tr><td>15
16
17</td><td rowspan="3">1,460,000</td><td rowspan="3">1,095,000</td><td>8,665,000</td></tr>
<tr><td>18
19</td><td>3,503,850[4]</td><td>7,828,850</td></tr>
<tr><td>20</td><td>4,340,000</td><td>8,665,000</td></tr>
</table>

[1] An additional 1,000,000 cu yds were dredged from an area to the left of the navigation channel, mile 74.22 to 74.84.

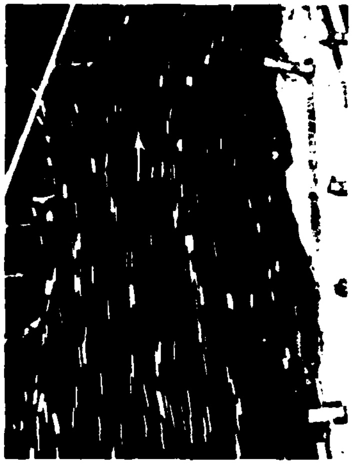
[2] Includes approximately 5,000,000 cu yds for 53- x 800-ft channel.

[3] An additional 1,300,000 cu yds were dredged from an area to the left of the navigation channel, mile 74.22 to 74.84.

[4] Longview turning basin was dredged to elev -40 CRD.

NOTES: 1. Quantities are based on the 1961 predredge survey.

2. Construction dredging of the navigation channel and Longview turning basin was to elev -45 CRD, except as indicated.



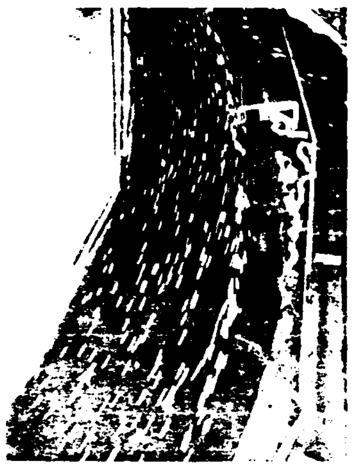
River Mile 77.0 to 76.0

River Mile 76.0 to 74.0

River Mile 75.0 to 73.5

River Mile 72.0 to 70.0

River Mile 70.5 to 67.5



River Mile 69.5 to 67.5

River Mile 67.5 to 65.5

River Mile 66.0 to 64.5

Photograph .. Surface flow patterns for base test (35 ft x 500 ft navigation channel), freshwater discharge 338,000 cfs.

River Mile 77.0 to 76.0

River Mile 76.0 to 74.0

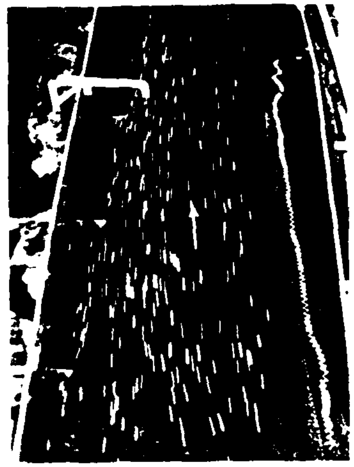
River Mile 75.0 to 73.5

River Mile 72.0 to 70.0

River Mile [illegible]

River Mile 69.5 to 67.5

River Mile 67.5 to 65.5



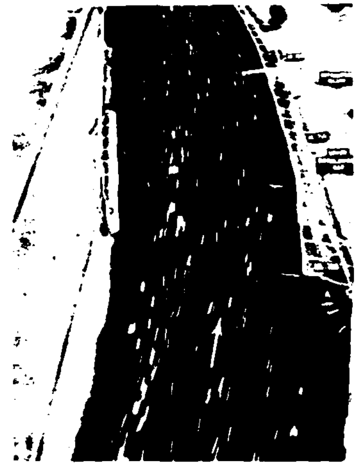
River Mile 66.0 to 64.5

Photograph 2. Surface flow patterns for improvement plan 2, freshwater discharge 338,000 cfs.

River Mile 77.0 to 76.0

River Mile 76.0 to 74.0

River Mile 75.0 to 73.5

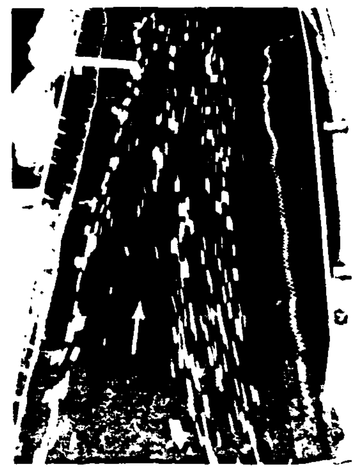


River Mile 72.0 to 70.0

River Mile 70.5 to 67.5

River Mile 69.5 to 67.5

River Mile 67.5 to 65.5



River Mile 66.0 to 64.5

Photograph 3. Surface flow patterns for improvement plan 3, floodwater discharge 338,[illegible]

River Mile 77.0 to 76.0

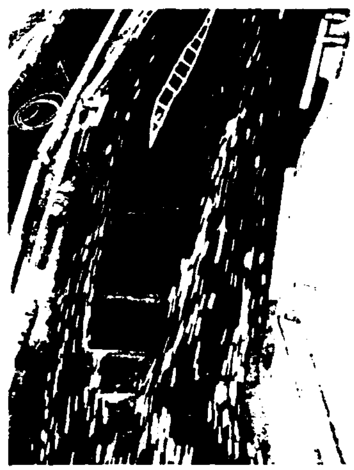
River Mile 76.0 to 74.0

River Mile 75.0 to 73.5

River Mile 72.0 to 70.0

River Mile 70.5 to 67.5

River Mile 69.5 to 67.5



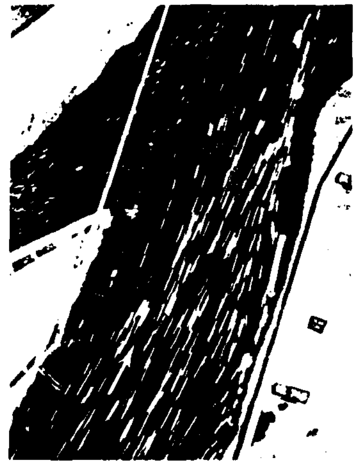
River Mile 67.5 to 65.5

River Mile 66.0 to 64.5

Photograph 4. Surface flow patterns for improvement plan [illegible], freshwater discharge 338,000 cfs.

River Mile 77.0 to 76.0

River Mile 76.0 to 74.0



River Mile 75.0 to 73.5

River Mile 72.0 to 70.0

River Mile 70.[illegible] to 67.5

River Mile 69.5 to 67.5

River Mile 67.5 to 65.5

River Mile 66.0 to 64.5

Photograph 5. Surface flow patterns for improvement plan 11, freshwater discharge 338,000 cfs.

River Mile 77.0 to 76.0

River Mile 76.0 to 74.0

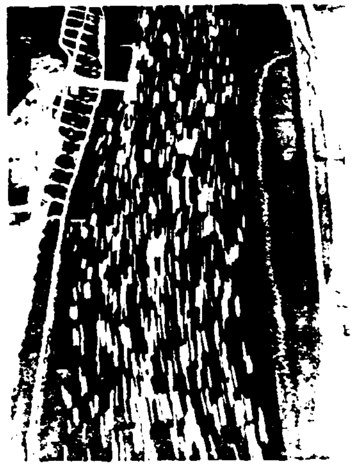
River Mile 75.0 to 73.5

River Mile 72.0 to 70.0

River Mile [illegible] to 67.5

River Mile 69.5 to 67.5

River Mile 67.5 to 65.5



River Mile 66.0 to 64.5

Photograph 6. Surface flow patterns for improvement plan [illegible]4, [illegible] water discharge 338,000 [illegible].

River Mile 77.0 to 76.0

River Mile 76.0 to 74.0

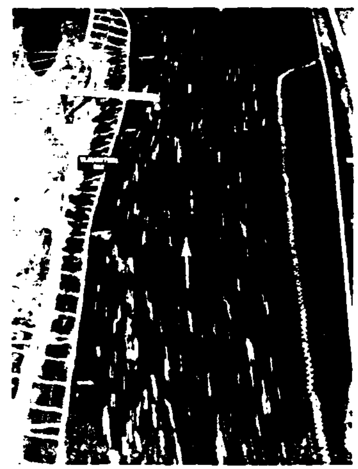
River Mile 75.0 to 73.5

River Mile 72.0 to 70.0

River Mile [illegible]

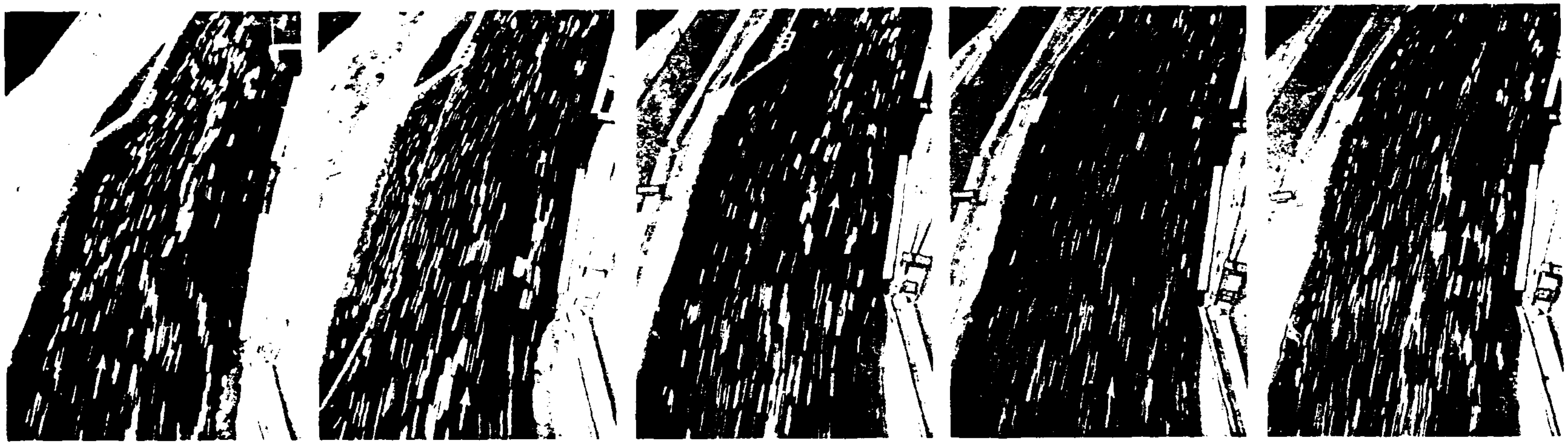
River Mile 69.5 to 67.5

River Mile 67.5 to 65.5



River Mile 66.0 to 64.5

[illegible]



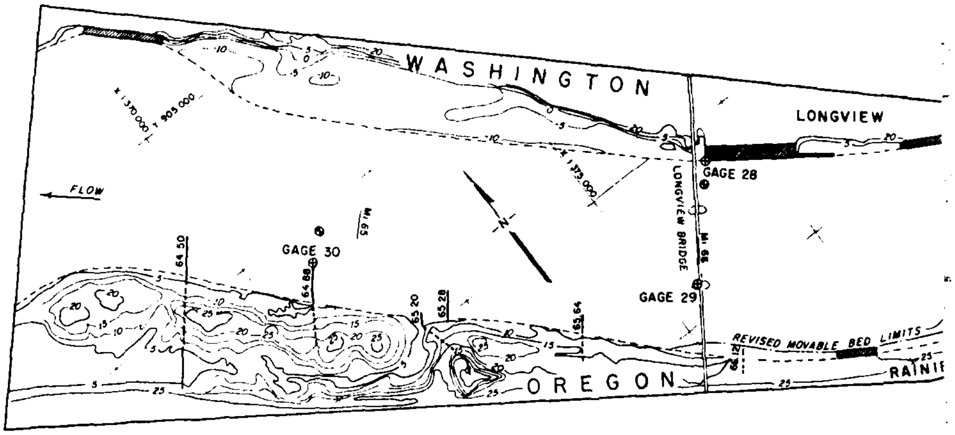
Plan 16 Plan 17 Plan 18 Plan 19 Plan 20

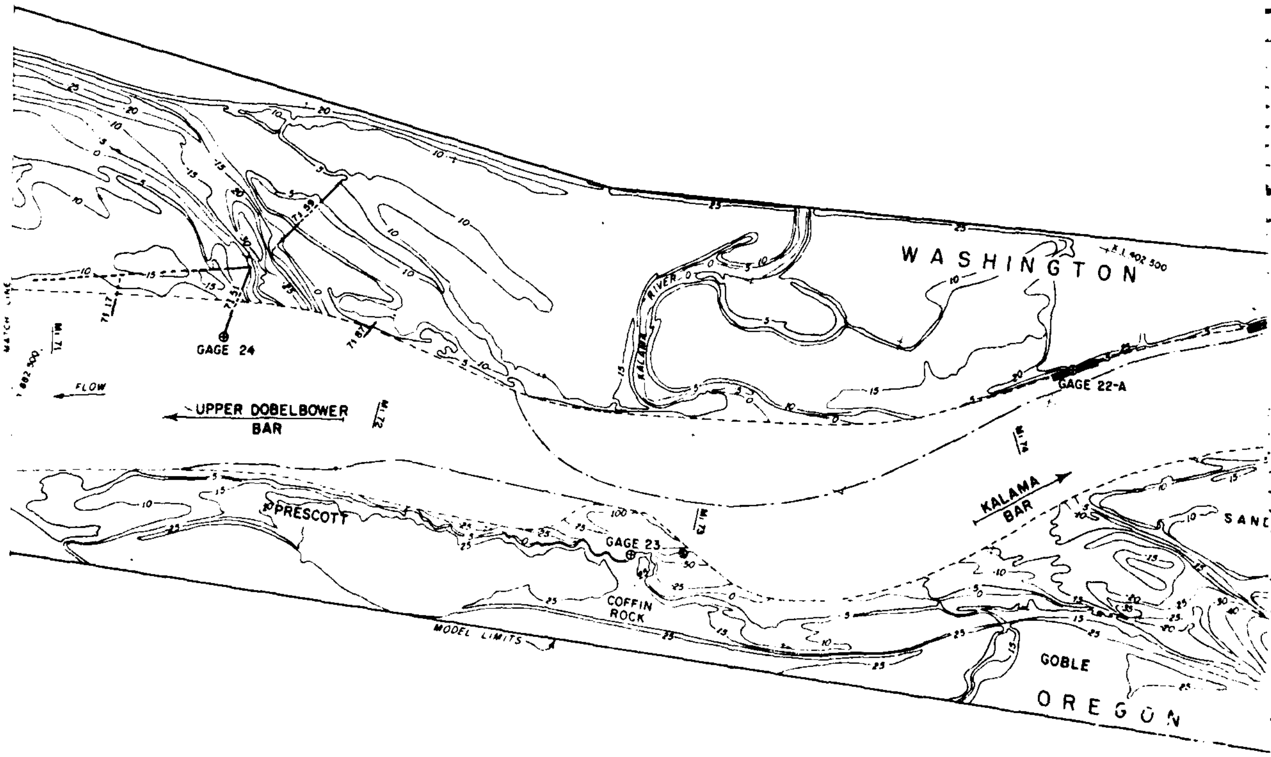
River Mile 67.5 to 65.5

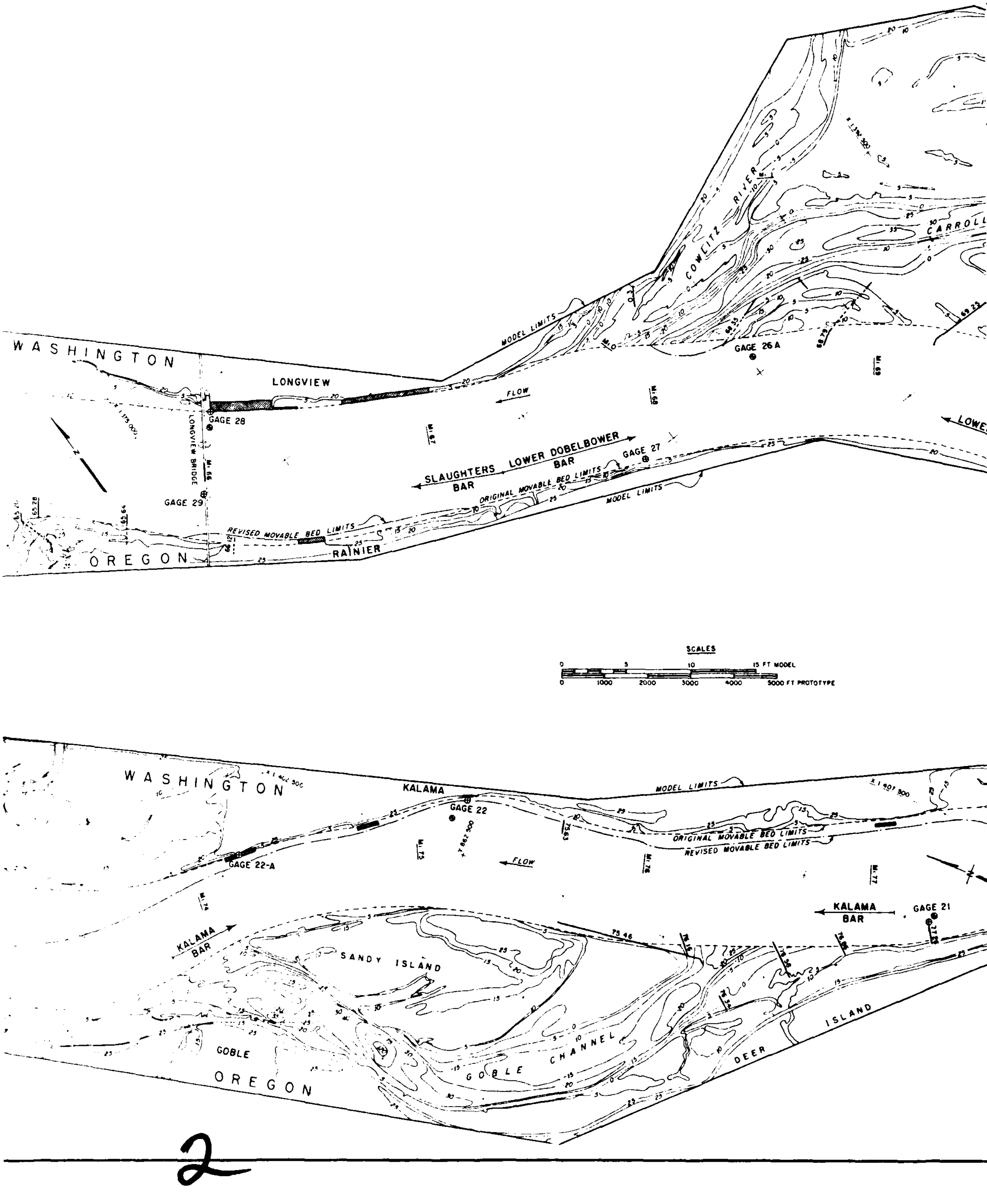
Plan 16 Plan 17 Plan 18 Plan 19 Plan 20

River Mile 66.0 to 64.5

[illegible] surface [illegible] patterns for improvement plans 16, 17, 18, 19, and 20, [illegible] discharge [illegible]


WASHINGTON
LONGVIEW
GAGE 28
LONGVIEW BRIDGE
FLOW
GAGE 30
GAGE 29
REVISED MOVABLE BED LIMITS
OREGON
RAINIE

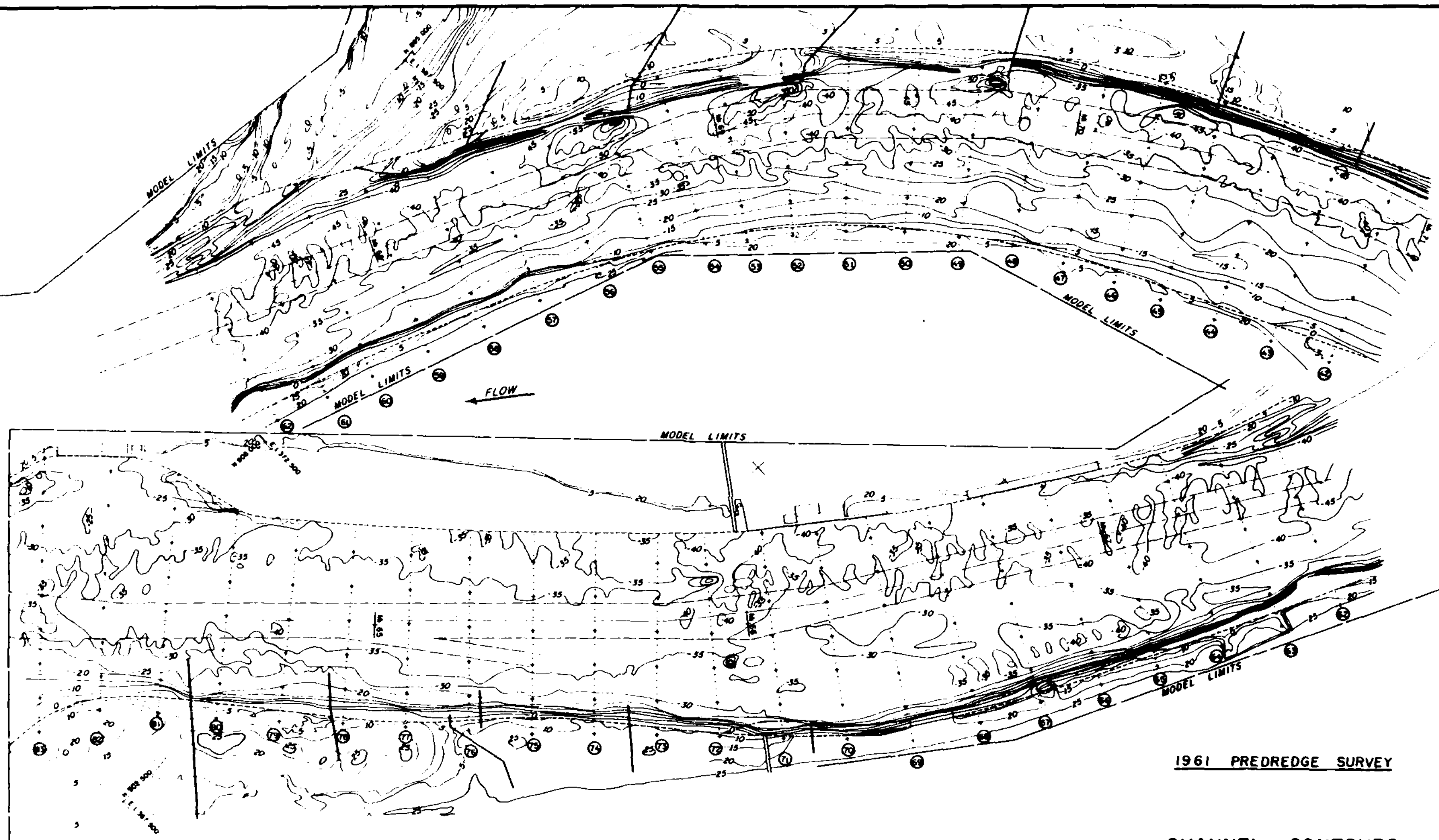

WASHINGTON
KALAMA RIVER
GAGE 24
GAGE 22-A
FLOW
UPPER DOBELBOWER BAR
KALAMA BAR
PRESCOTT
GAGE 23
COFFIN ROCK
MODEL LIMITS
GOBLE
OREGON


WASHINGTON
LONGVIEW
COWLITZ RIVER
CARROLL
MODEL LIMITS
GAGE 26 A
GAGE 28
FLOW
LONGVIEW BRIDGE
SLAUGHTERS BAR
LOWER DOBELBOWER BAR
GAGE 27
GAGE 29
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
OREGON
RAINIER
SCALES
0 5 10 15 FT MODEL
0 1000 2000 3000 4000 5000 FT PROTOTYPE
WASHINGTON
KALAMA
GAGE 22
GAGE 22-A
MODEL LIMITS
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
FLOW
KALAMA BAR
GAGE 21
KALAMA BAR
SANDY ISLAND
GOBLE
GOBLE CHANNEL
OREGON
DEER ISLAND

2

MODEL LAYOUT

3



1961 PREDREDGE SURVEY

CHANNEL CONTOURS
MILE 64 TO MILE 71

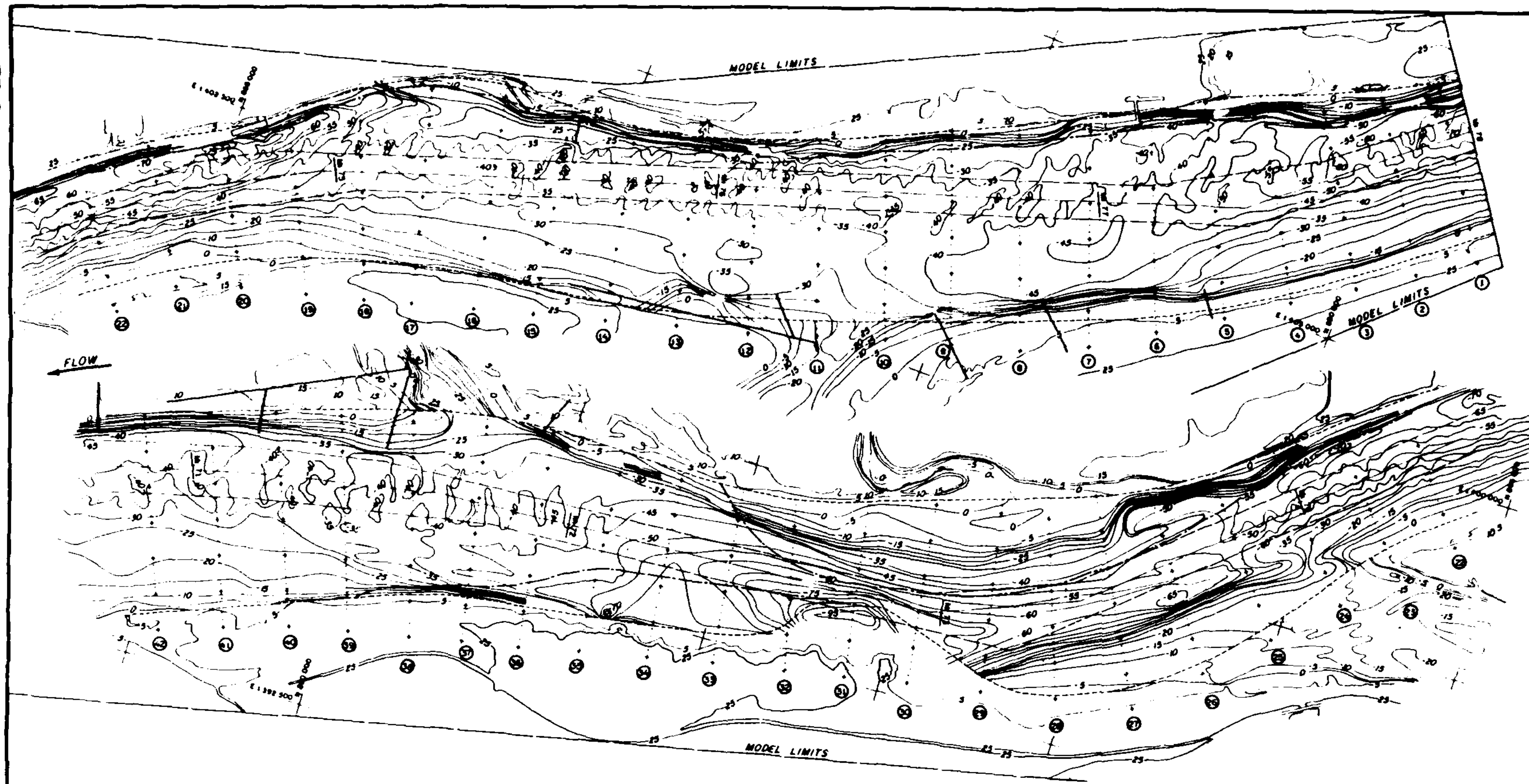
LEGEND

- MODEL SOUNDING RANGES
- MOVABLE BED ''ITS
- REVISED MOVABLE BED LIMITS

NOTE

OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE REFERRED TO FEET ABOVE OR BELOW (-) MSL

PLATE 2



1961 PREDREDGE SURVEY

LEGEND

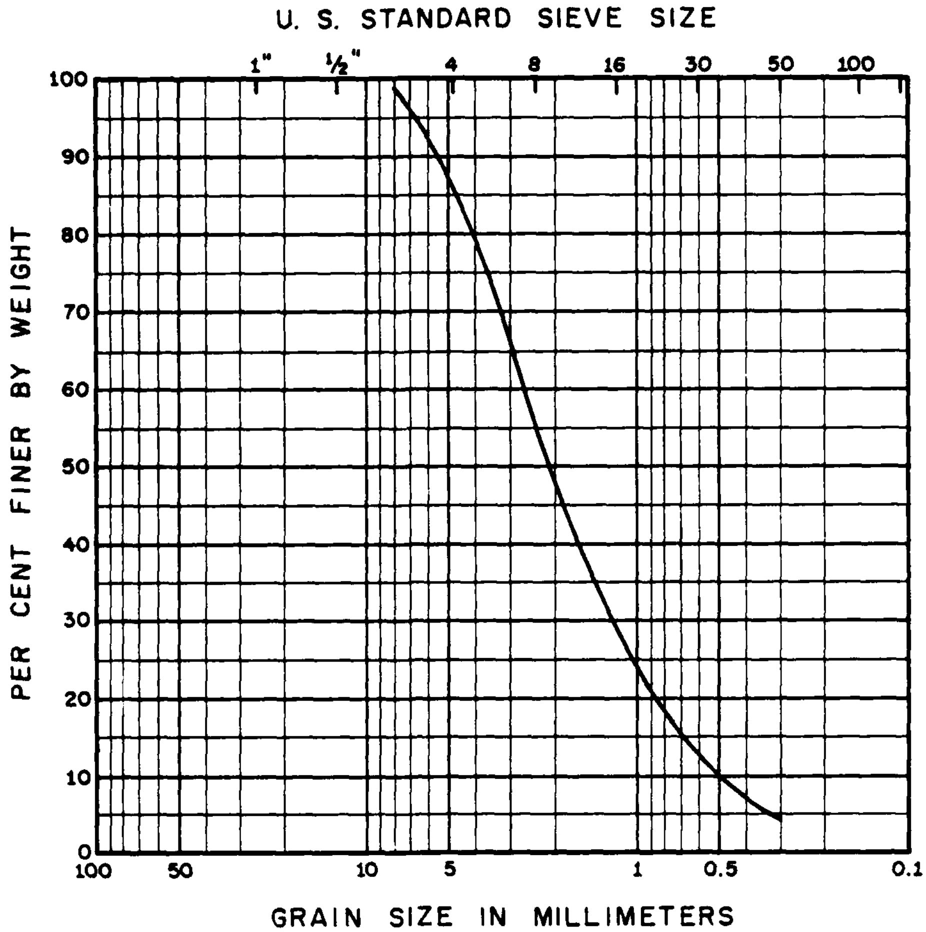
- (33) MODEL SOUNDING RANGES
- ---- MOVABLE BED LIMITS
- —·— REVISED MOVABLE BED LIMITS

NOTE

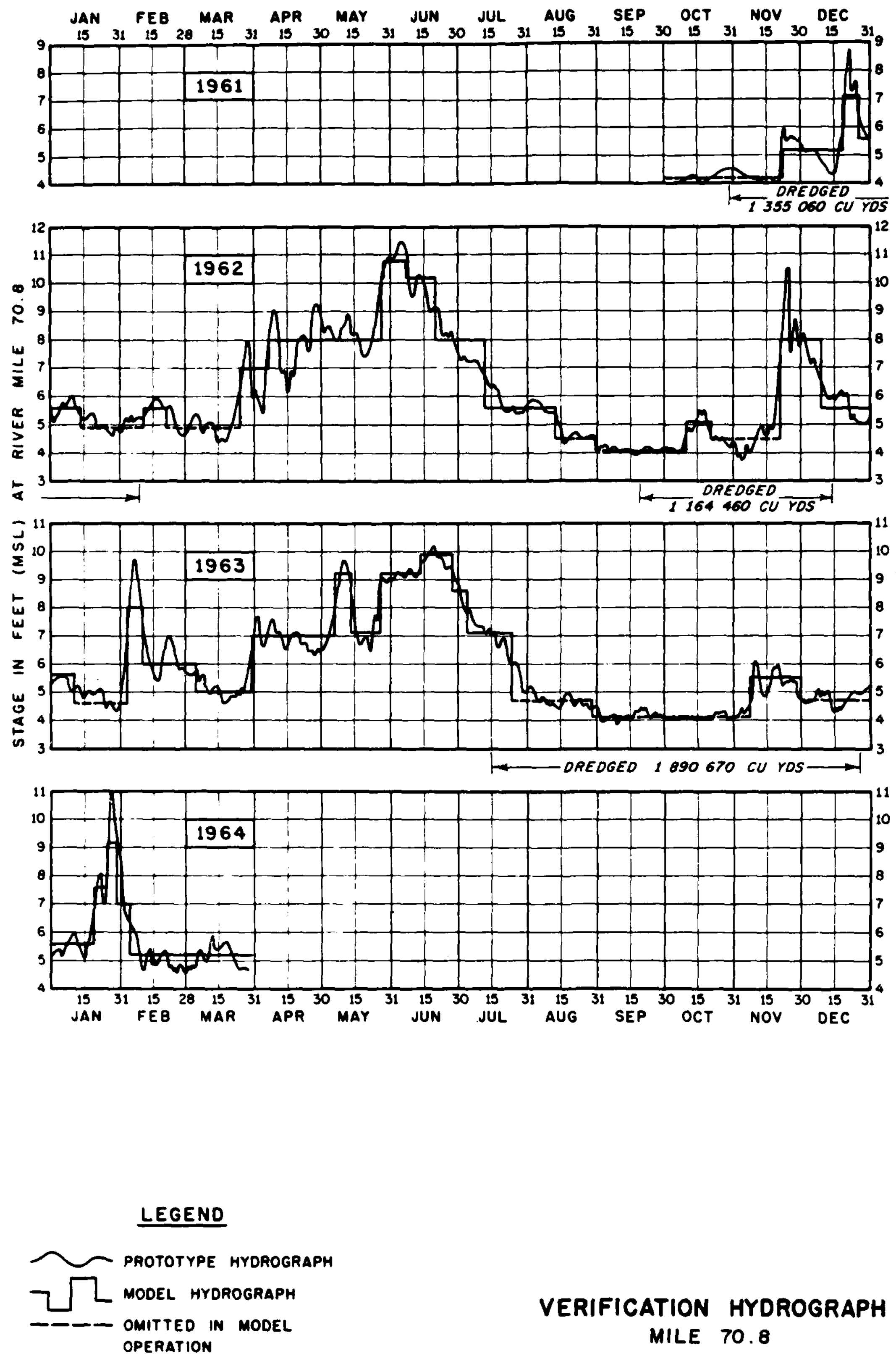
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE REFERRED TO FEET ABOVE OR BELOW (-) MSL

CHANNEL CONTOURS
MILE 71 TO MILE 78

PLATE 3



GRAIN-SIZE DISTRIBUTION OF MODEL BED MATERIAL



VERIFICATION HYDROGRAPH
MILE 70.8

PLATE 5

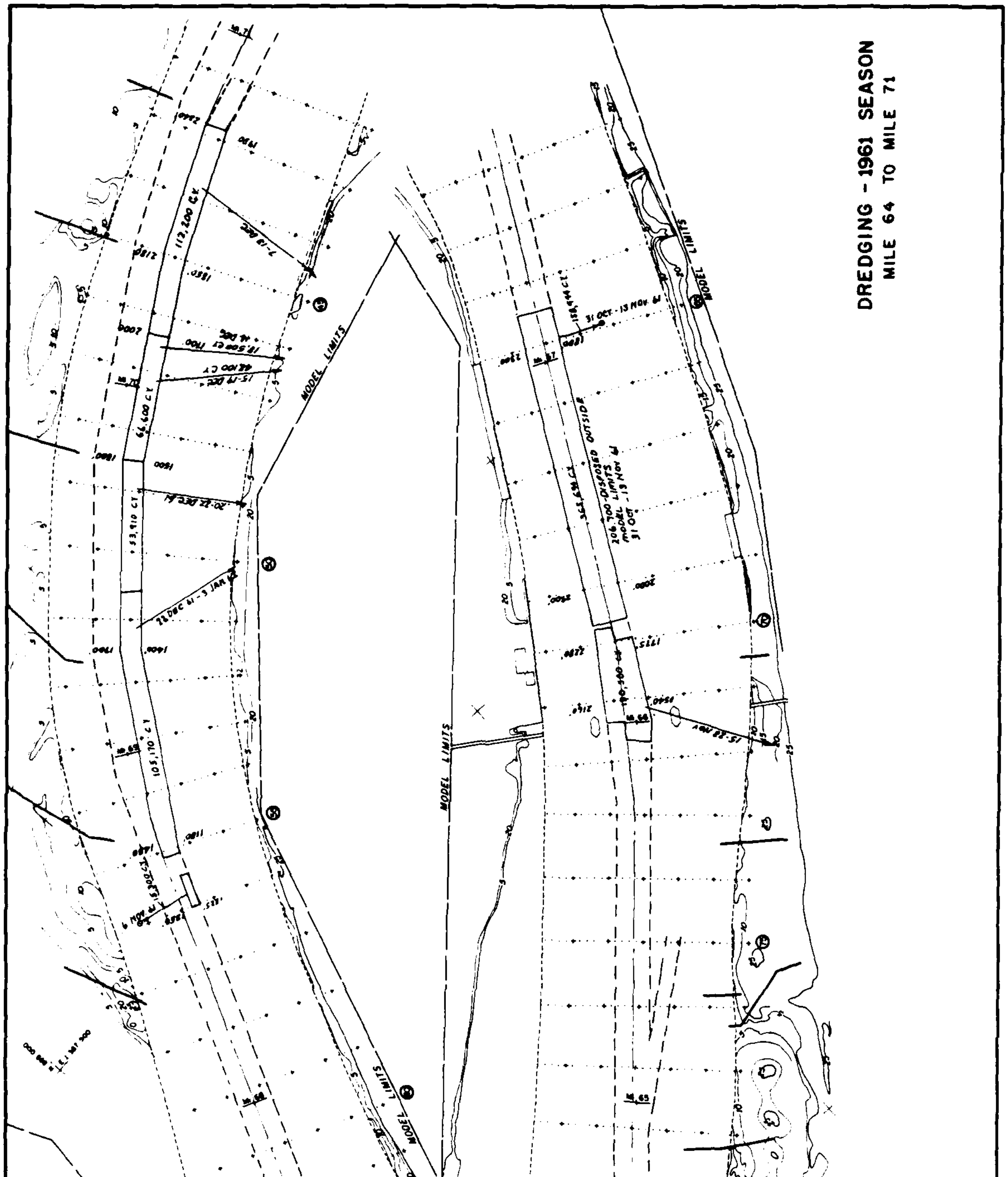


PLATE 6

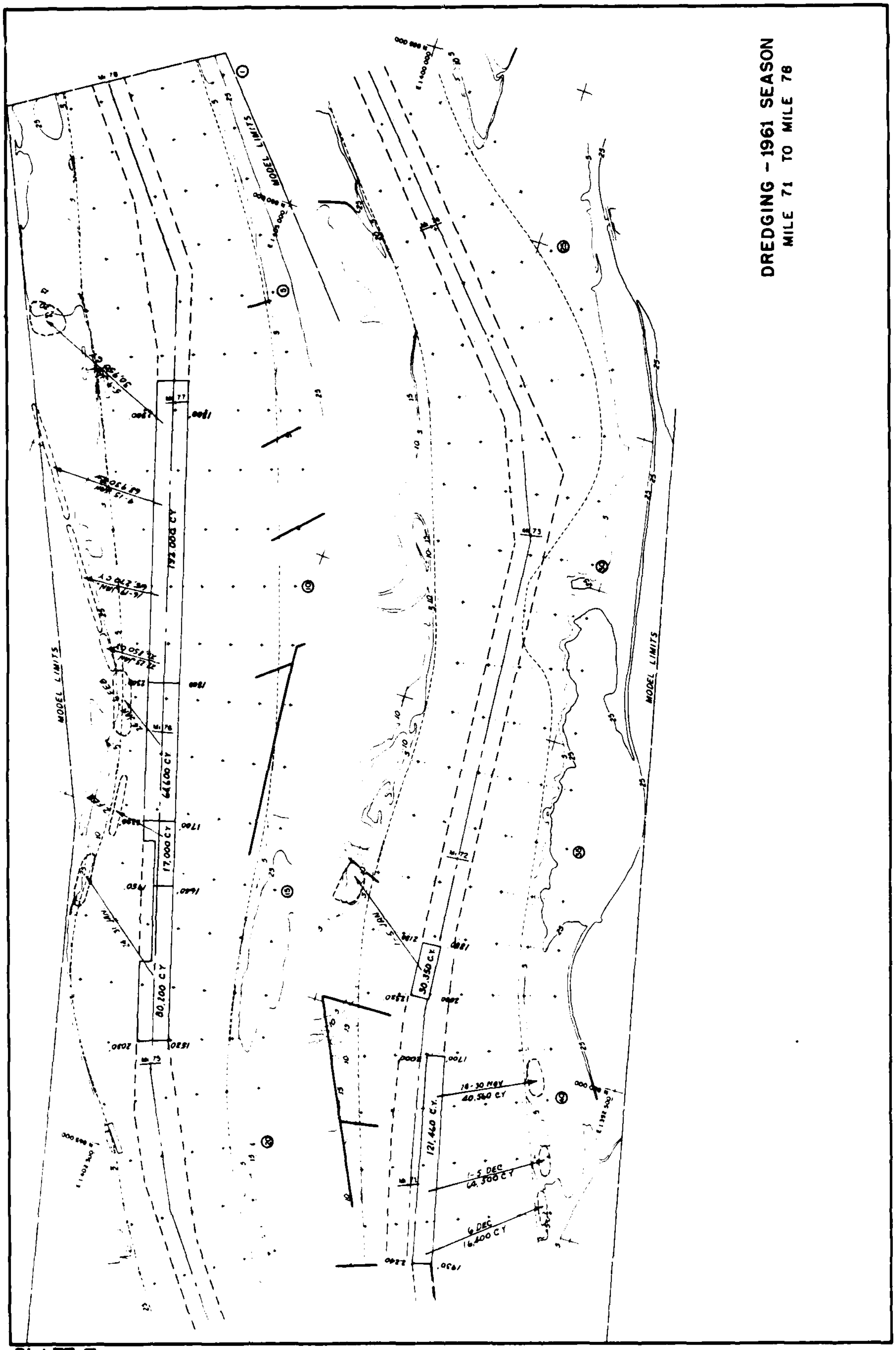

DREDGING - 1961 SEASON
MILE 71 TO MILE 78
MODEL LIMITS
193,000 CY
64,600 CY
17,000 CY
80,200 CY
30,350 C.Y.
121,460 C.Y.
16-30 NOV
40,560 CY
1-5 DEC
64,300 CY
6 DEC
16,400 CY

PLATE 7

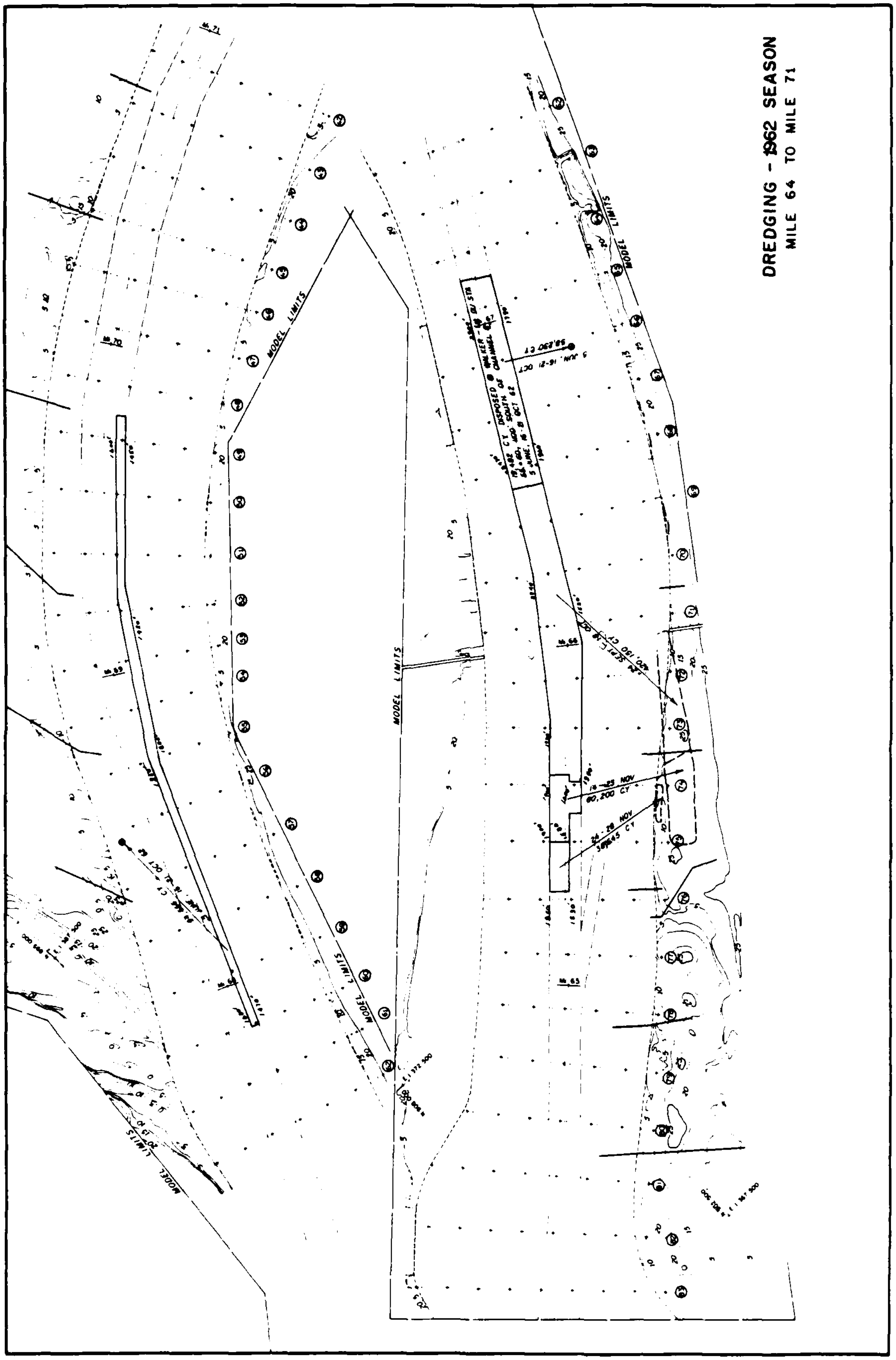


PLATE 8

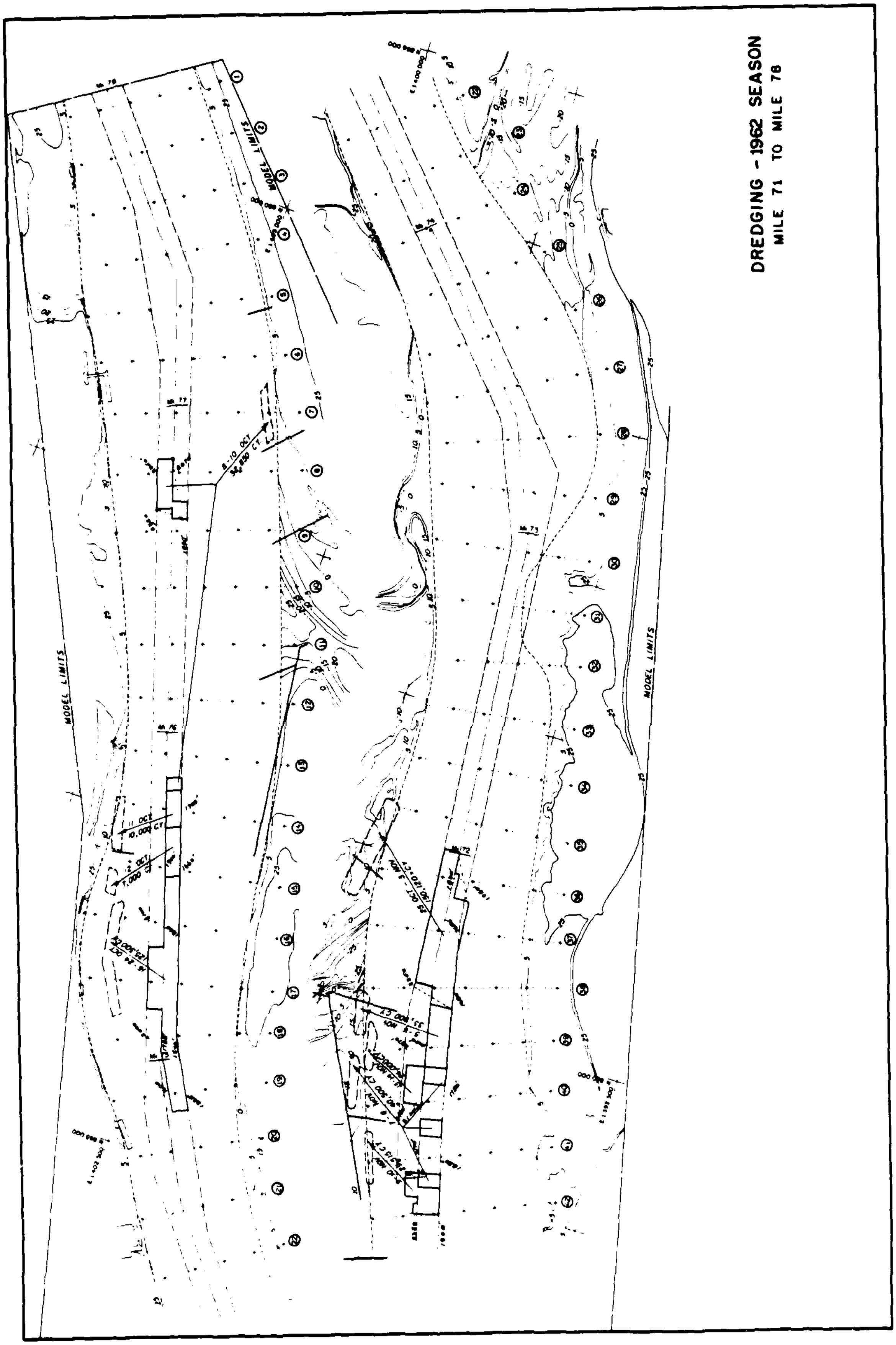

DREDGING - 1962 SEASON
MILE 71 TO MILE 78
MODEL LIMITS
MODEL LIMITS
MODEL LIMITS

PLATE 9

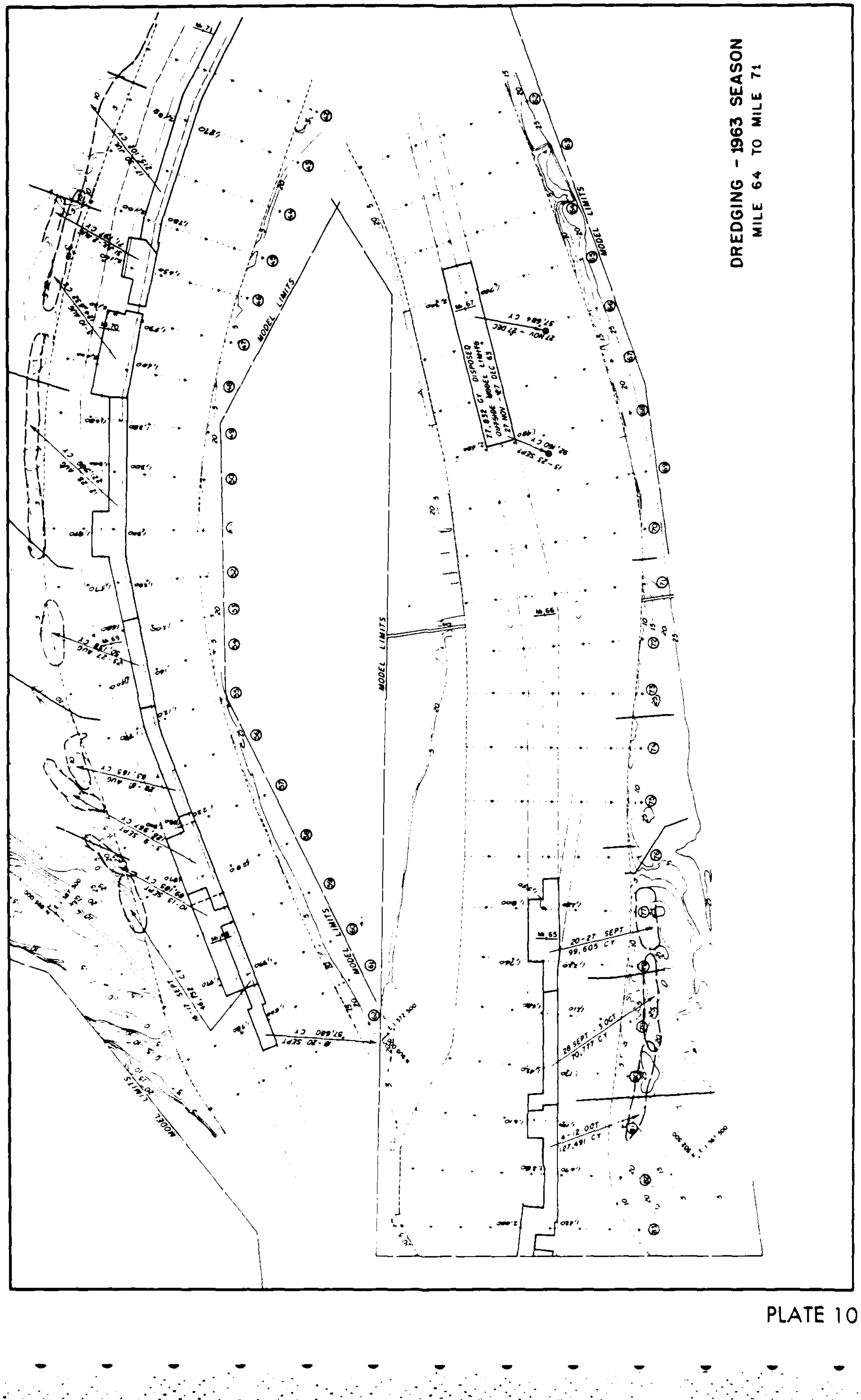
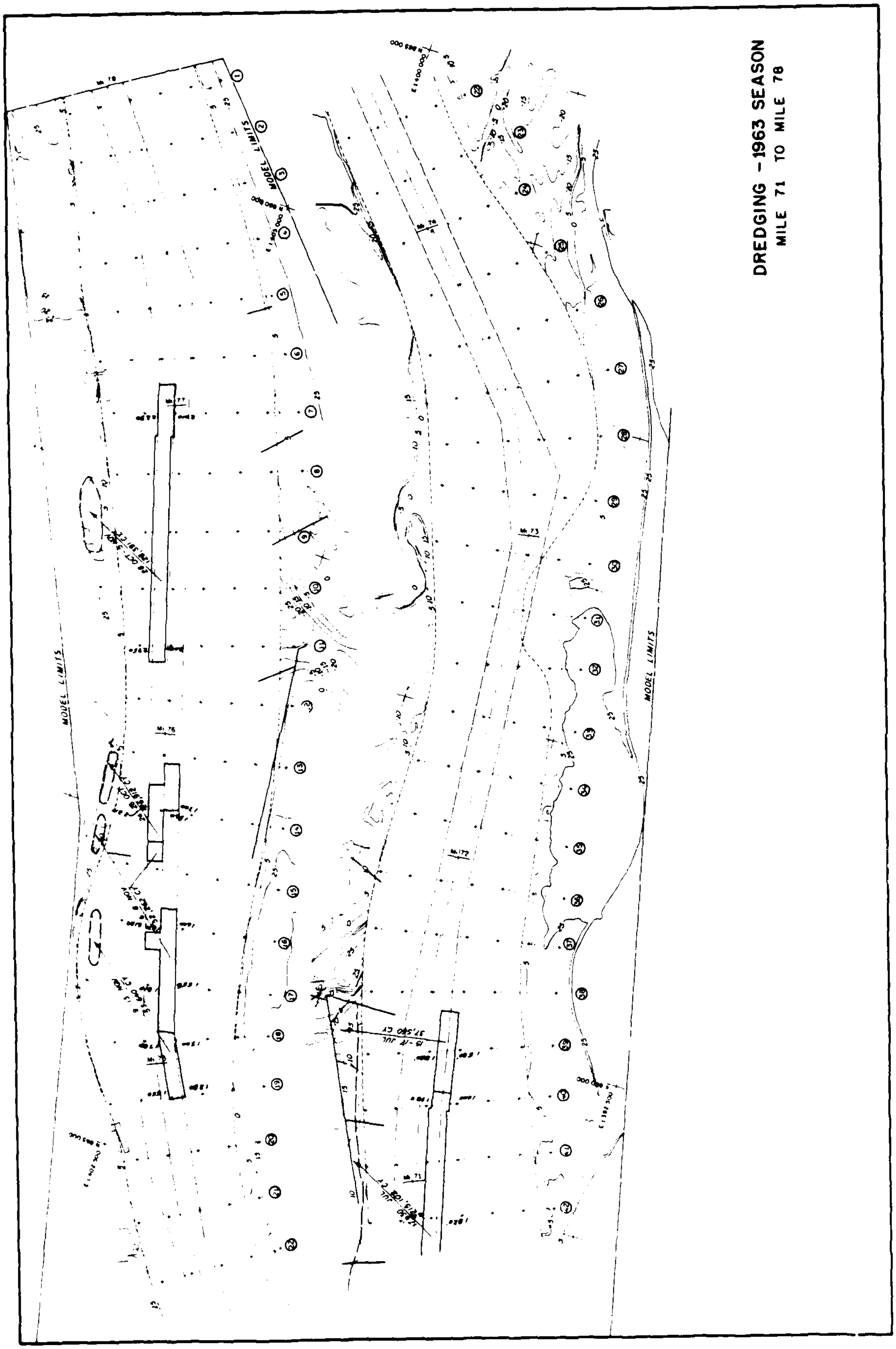

DREDGING - 1963 SEASON
MILE 64 TO MILE 71
MODEL LIMITS
20-27 SEPT
99,605 CY
28 SEPT - 3 OCT
70,777 CY
4-12 OCT
127,491 CY

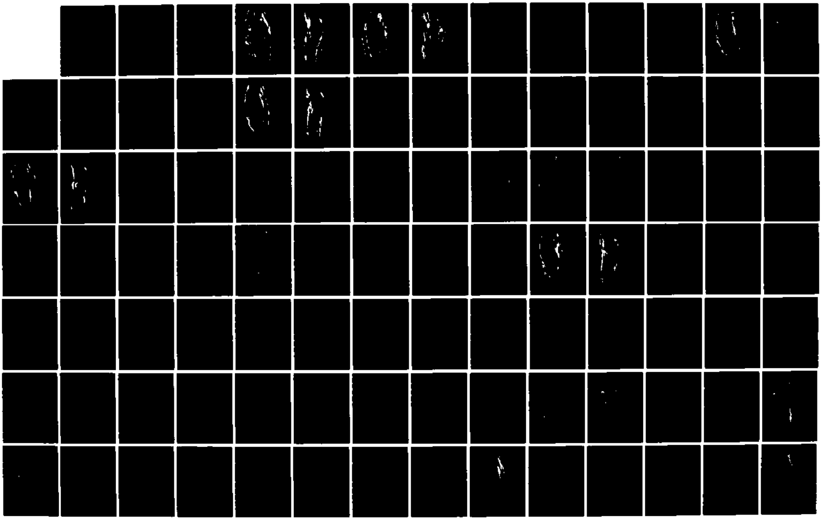
PLATE 10

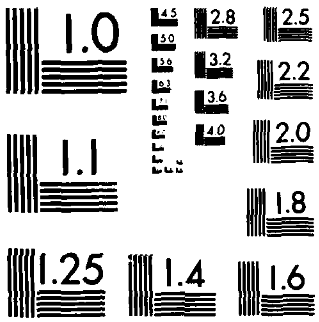


DREDGING – 1963 SEASON
MILE 71 TO MILE 78

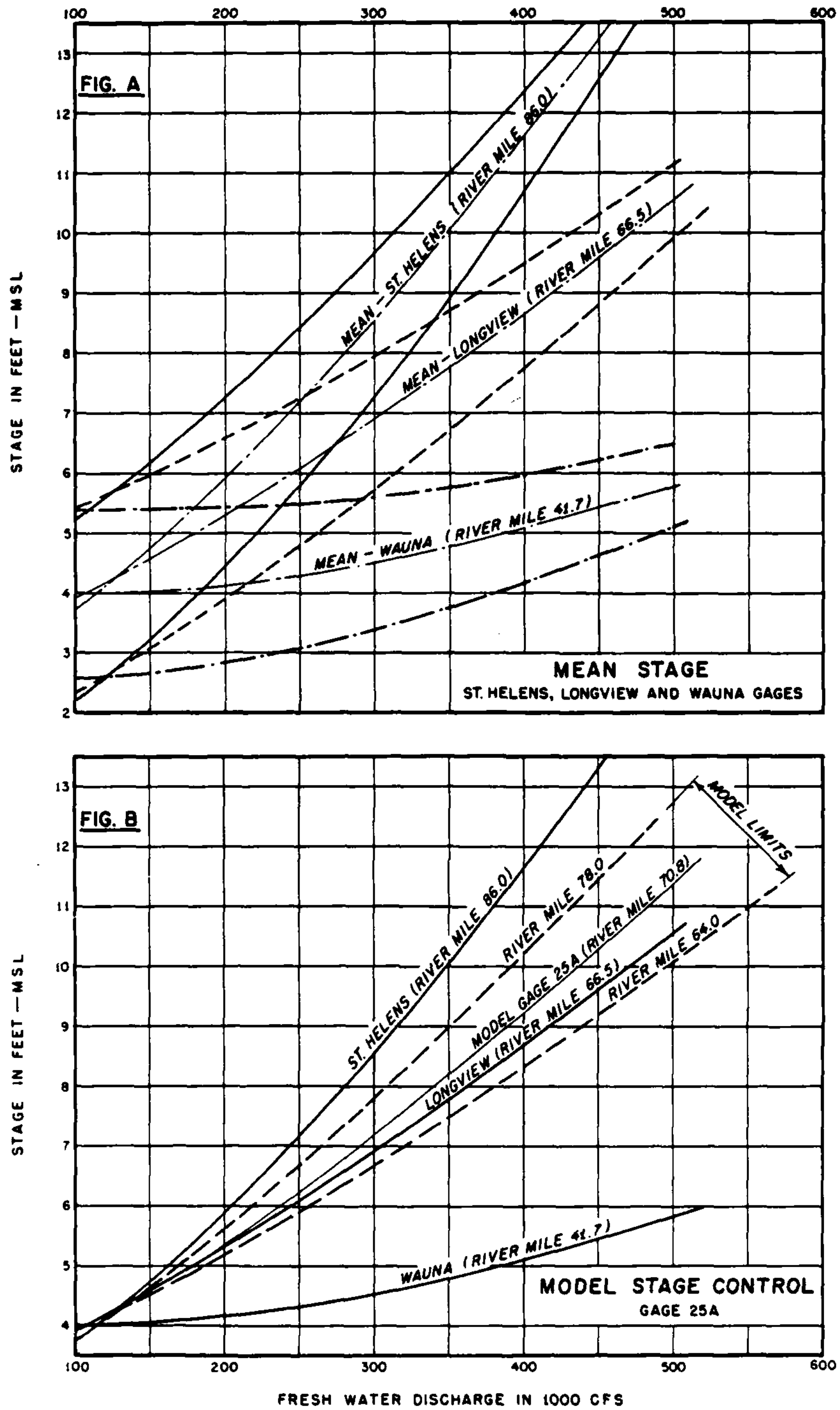
PLATE 11

AD-A149 374 NAVIGATION CHANNEL IMPROVEMENT COLUMBIA RIVER OREGON 2/
AND WASHINGTON - LON..(U) ARMY ENGINEER DIV NORTH
PACIFIC BONNEVILLE OR DIV HYDRAULIC L.. SEP 84
UNCLASSIFIED TR-118-1 F/G 13/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



NOTE
DATA FROM AUTOMATIC WATER-SURFACE RECORDERS AT ST. HELENS AND WAUNA OREGON, AND LONGVIEW, WASHINGTON

STAGE-DISCHARGE CURVES
OCTOBER 1961 TO MARCH 1964

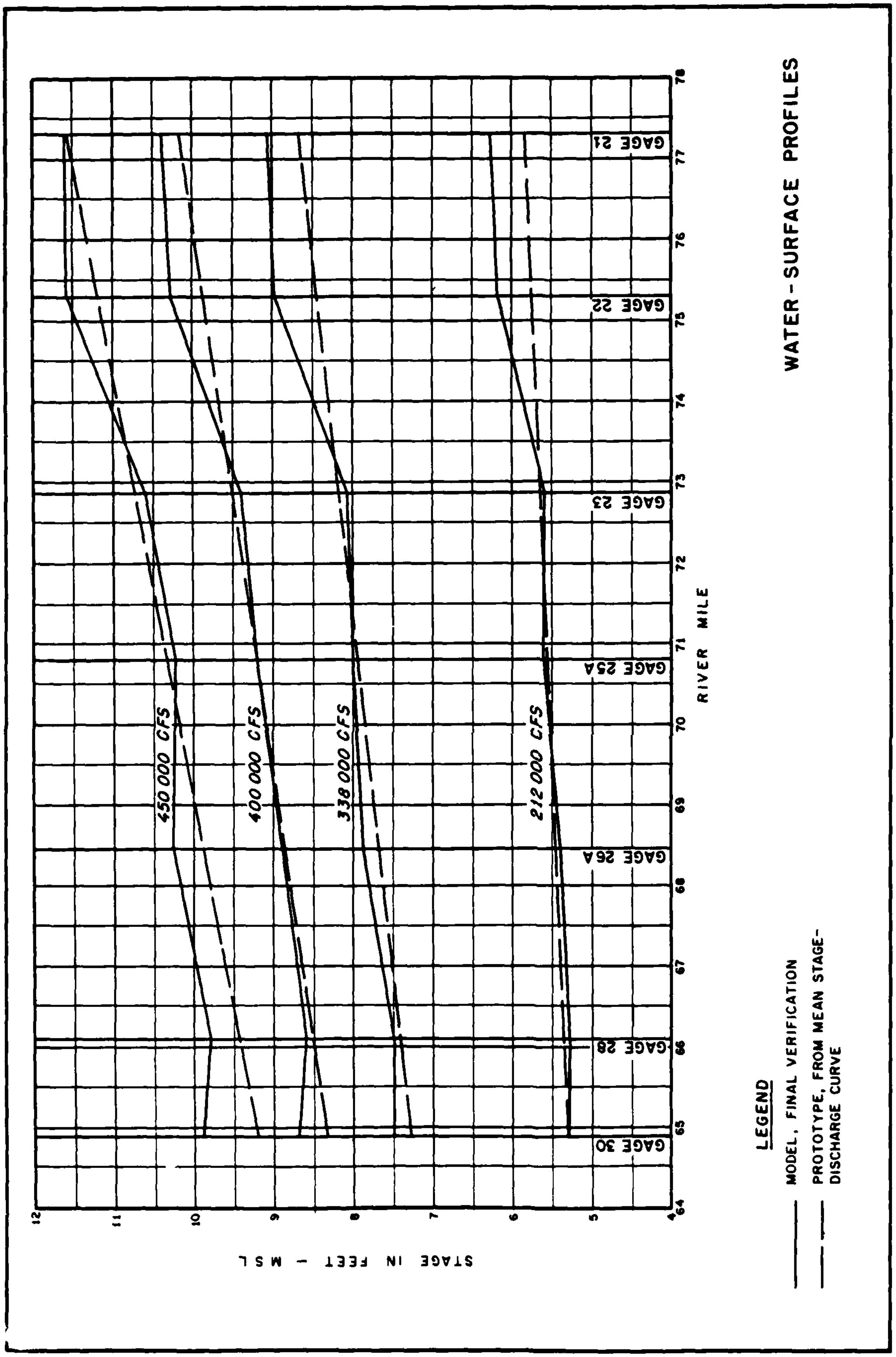
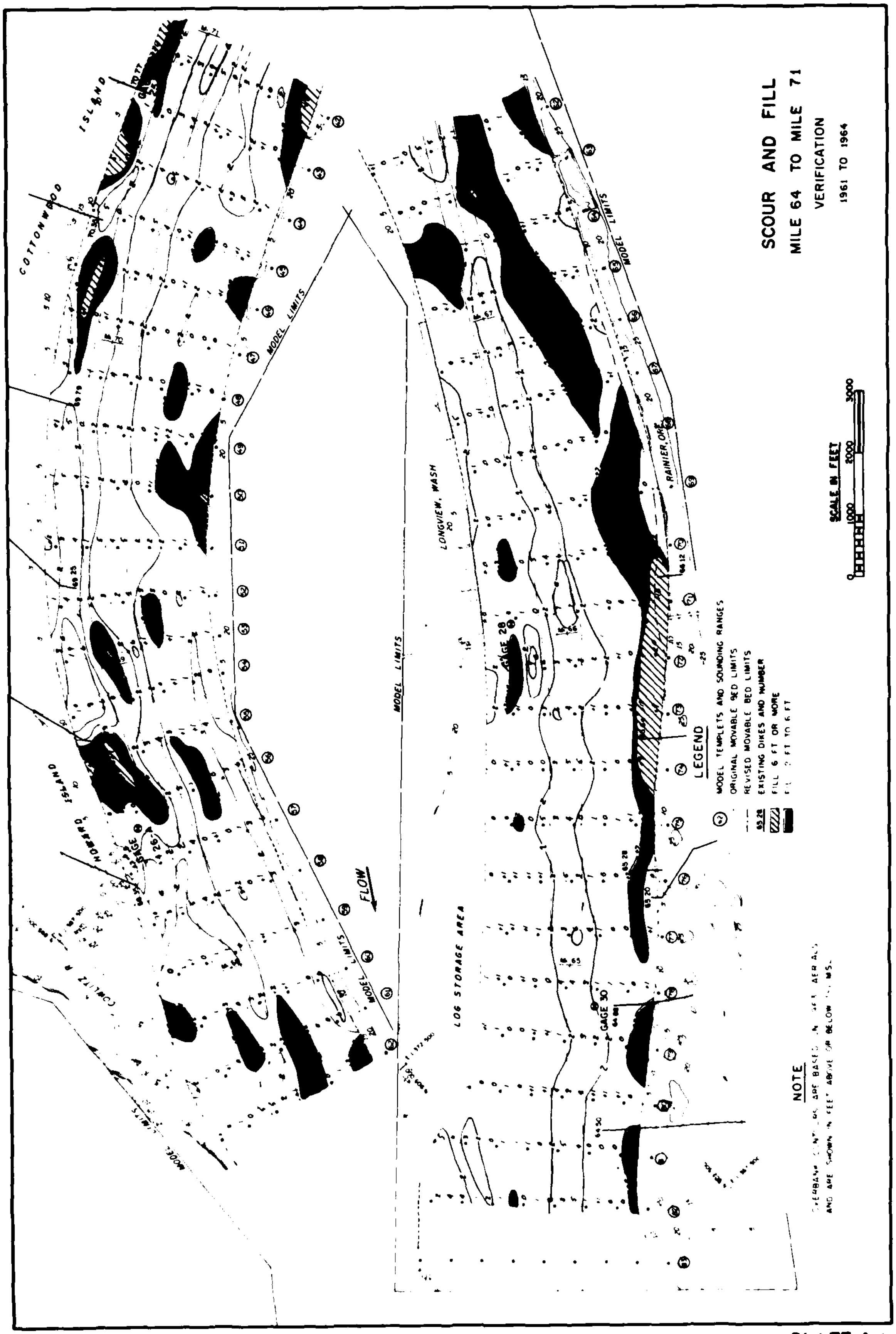
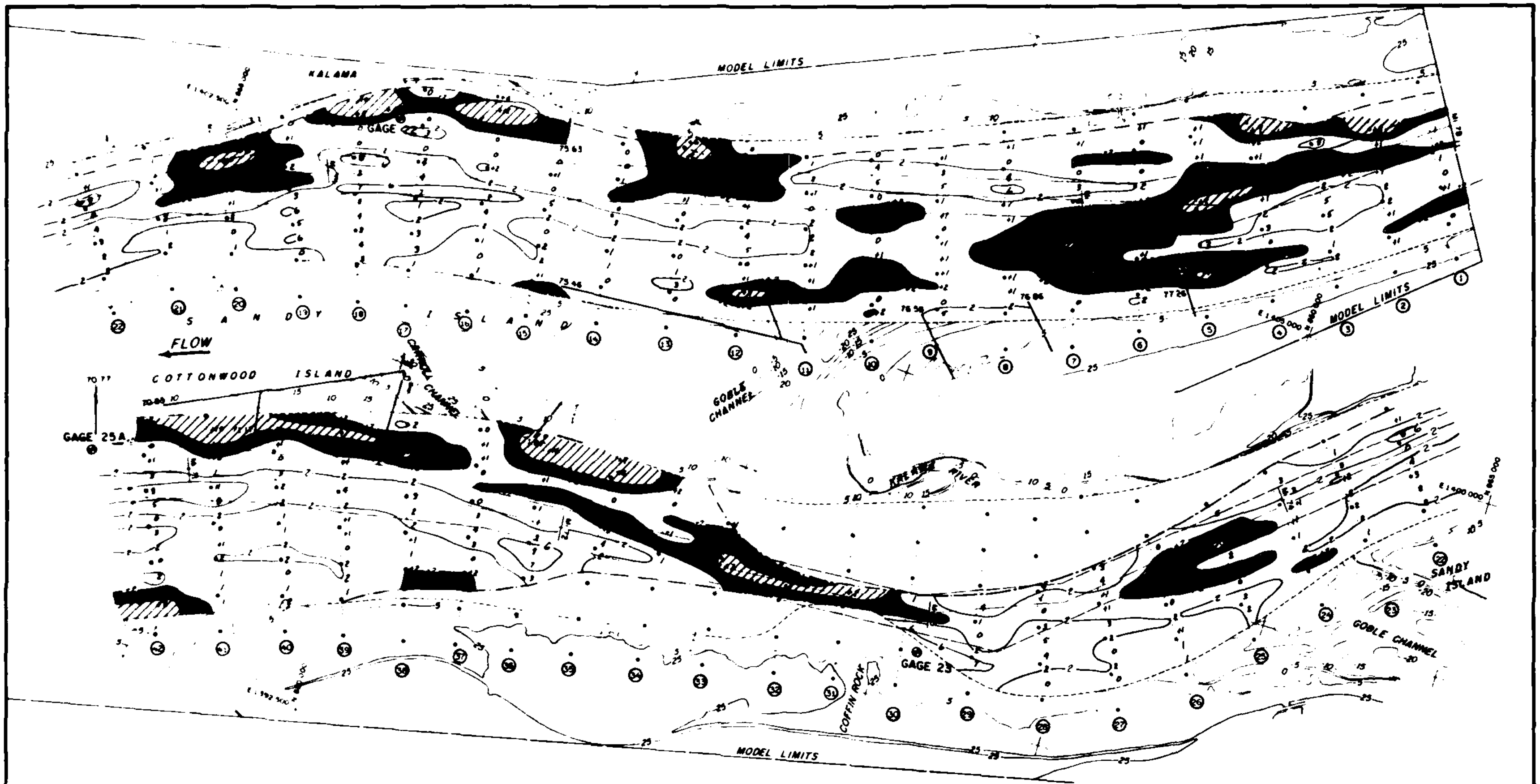

WATER - SURFACE PROFILES
GAGE 21
GAGE 22
GAGE 23
GAGE 25A
GAGE 26A
GAGE 28
GAGE 30
450 000 CFS
400 000 CFS
338 000 CFS
212 000 CFS
RIVER MILE
STAGE IN FEET - MSL
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
4
5
6
7
8
9
10
11
12
LEGEND
MODEL, FINAL VERIFICATION
PROTOTYPE, FROM MEAN STAGE-DISCHARGE CURVE

PLATE 13



SCOUR AND FILL
MILE 64 TO MILE 71
VERIFICATION
1961 TO 1964
SCALE IN FEET
0 1000 2000 3000
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
EXISTING DIKES AND NUMBER
FILL 6 FT OR MORE
NOTE
COTTONWOOD ISLAND
HOWARD ISLAND
MODEL LIMITS
FLOW
LONGVIEW WASH
LOG STORAGE AREA
RAINIER, ORE.
GAGE 28
GAGE 30

PLATE 14



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- EXISTING DIKES AND NUMBER
- FILL 6 FT OR MORE
- FILL 2 FT TO 6 FT

SCALE IN FEET

0 1000 2000 3000

NOTE

OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL

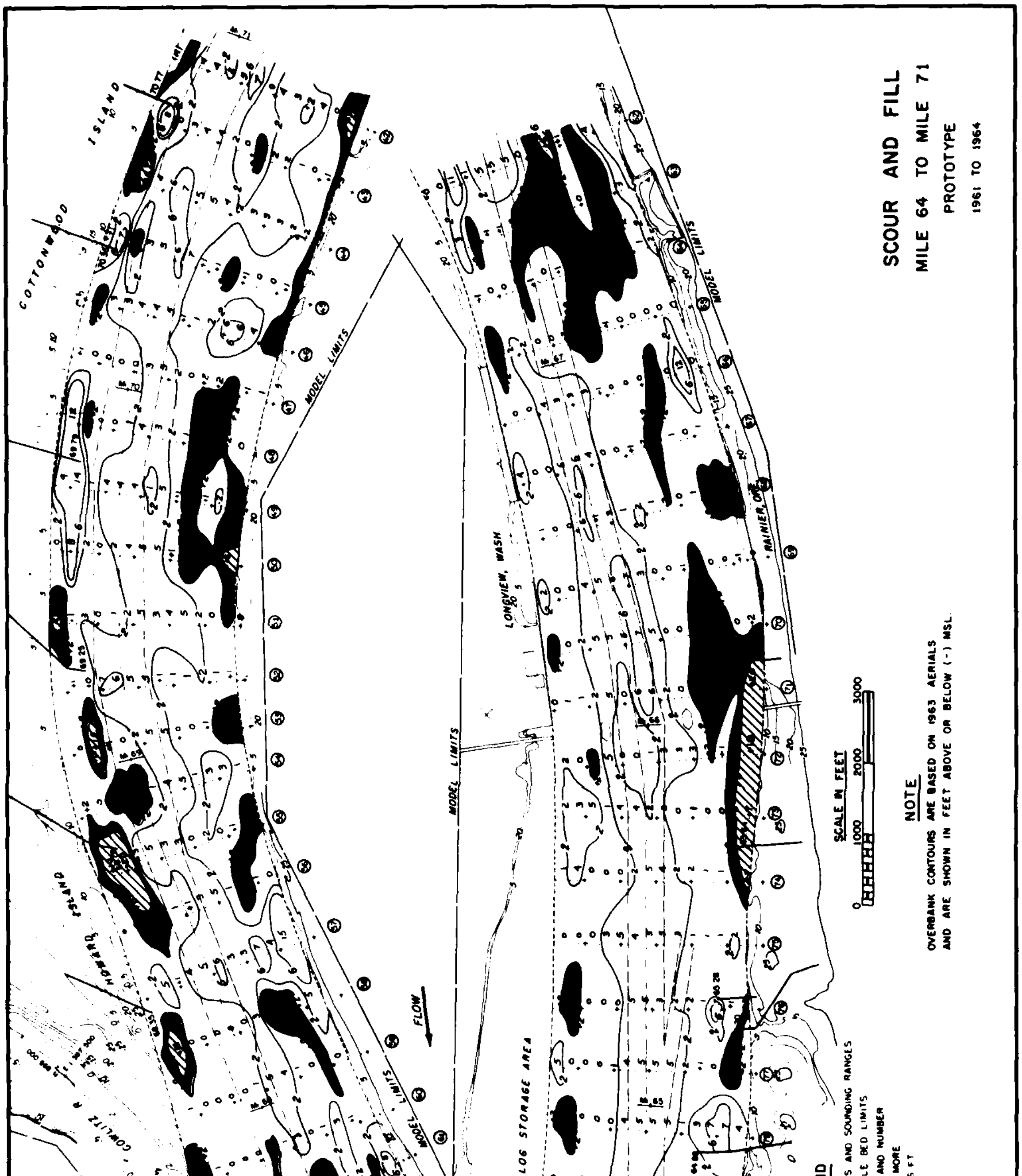
SCOUR AND FILL

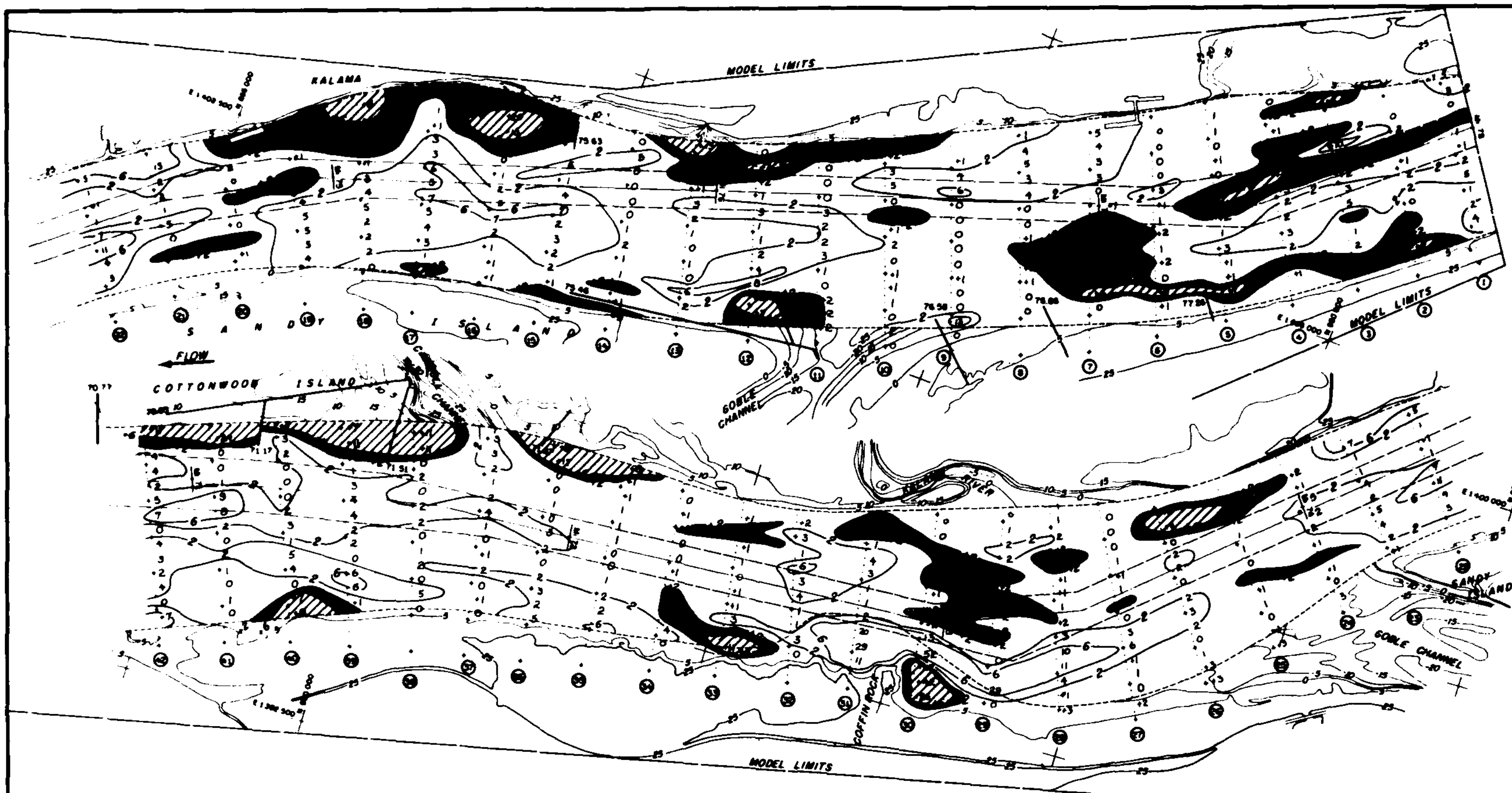
MILE 71 TO MILE 78

VERIFICATION

1961 TO 1964

PLATE 15


SCOUR AND FILL
MILE 64 TO MILE 71
PROTOTYPE
1961 TO 1964
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL.
SCALE IN FEET
0 1000 2000 3000
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
EXISTING DIKES AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
COTTONWOOD ISLAND
HOWARD ISLAND
COWLITZ R
LOG STORAGE AREA
LONGVIEW WASH
RAINIER
MODEL LIMITS
FLOW



LEGEND

- (42) MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- 5.28 EXISTING DIKES AND NUMBER
- FILL 6 FT OR MORE
- FILL 2 FT TO 6 FT

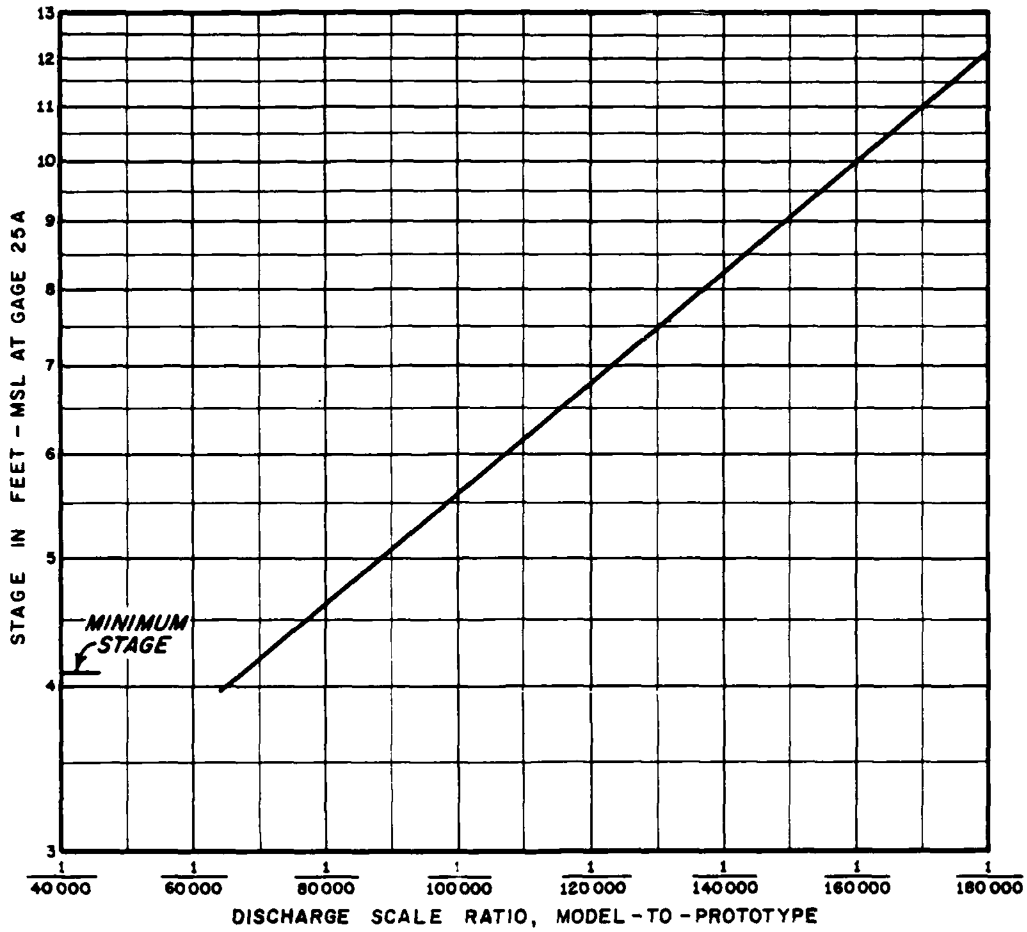
SCALE IN FEET

0 1000 2000 3000

NOTE

OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL.

SCOUR AND FILL
MILE 71 TO MILE 78
PROTOTYPE
1961 TO 1964



STAGE - DISCHARGE RELATION

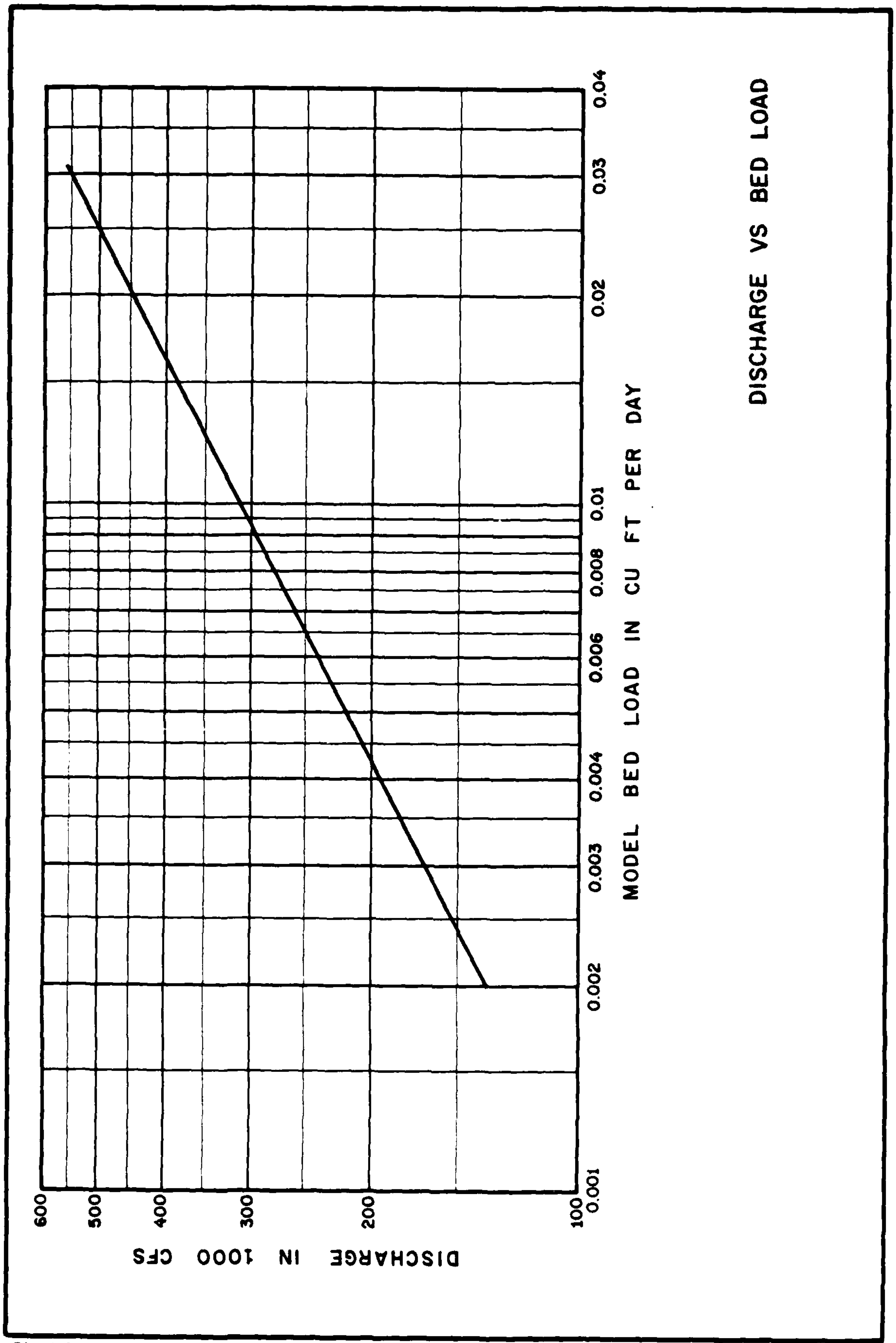
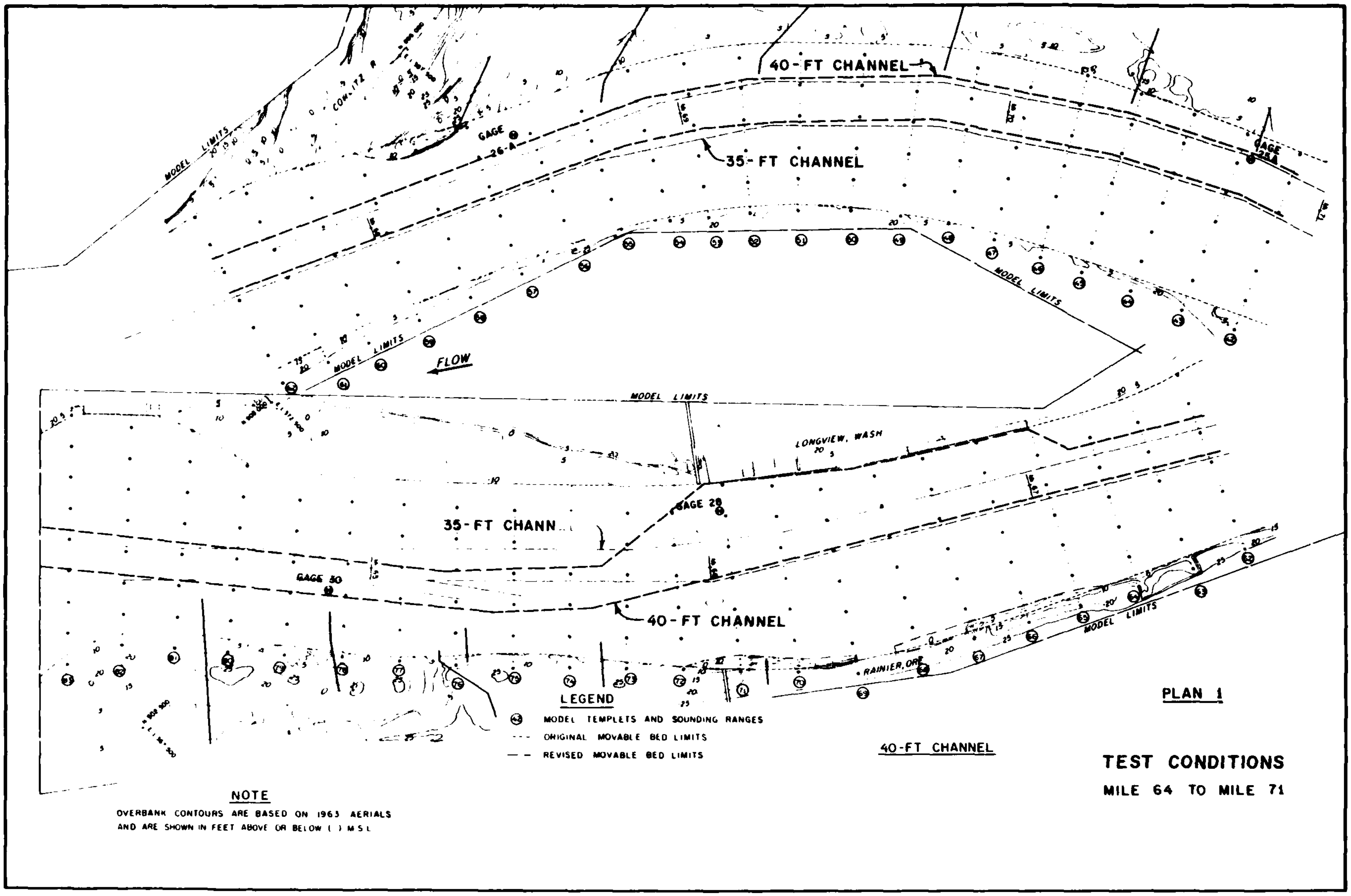

DISCHARGE VS BED LOAD
MODEL BED LOAD IN CU FT PER DAY
0.001
0.002
0.003
0.004
0.006
0.008
0.01
0.02
0.03
0.04
DISCHARGE IN 1000 CFS
100
200
300
400
500
600

PLATE 19


40-FT CHANNEL
35-FT CHANNEL
GAGE 26-A
GAGE 28A
MODEL LIMITS
FLOW
LONGVIEW, WASH
GAGE 28
35-FT CHANN...
GAGE 30
40-FT CHANNEL
RAINIER, ORE
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
40-FT CHANNEL
PLAN 1
TEST CONDITIONS
MILE 64 TO MILE 71
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS
AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L

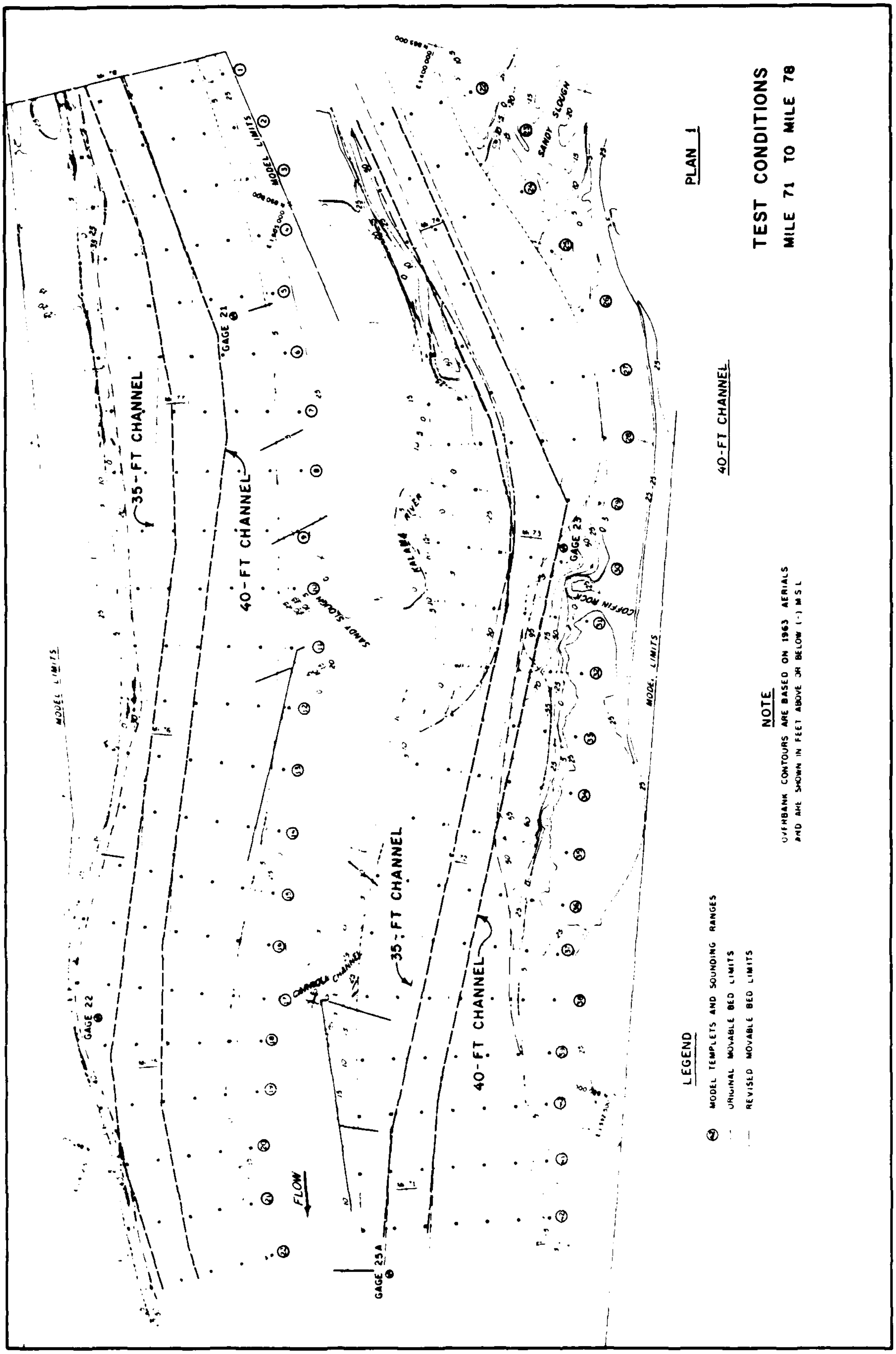

TEST CONDITIONS
MILE 71 TO MILE 78
PLAN 1
40-FT CHANNEL
35-FT CHANNEL
GAGE 21
GAGE 22
GAGE 23
GAGE 25A
SANDY SLOUGH
KALAMA RIVER
COFFIN ROCK
CARROLLS CHANNEL
MODEL LIMITS
FLOW
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL

PLATE 21

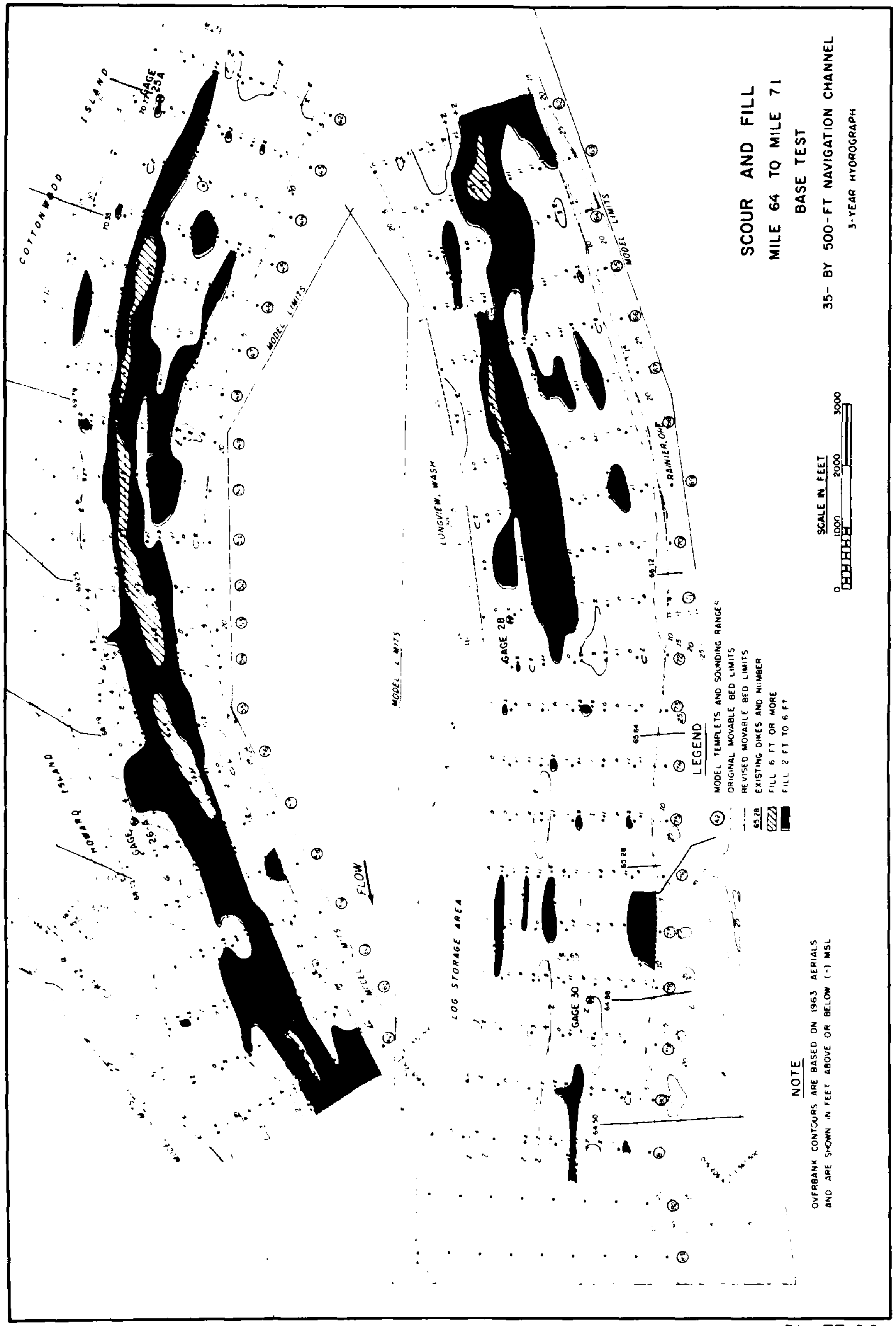
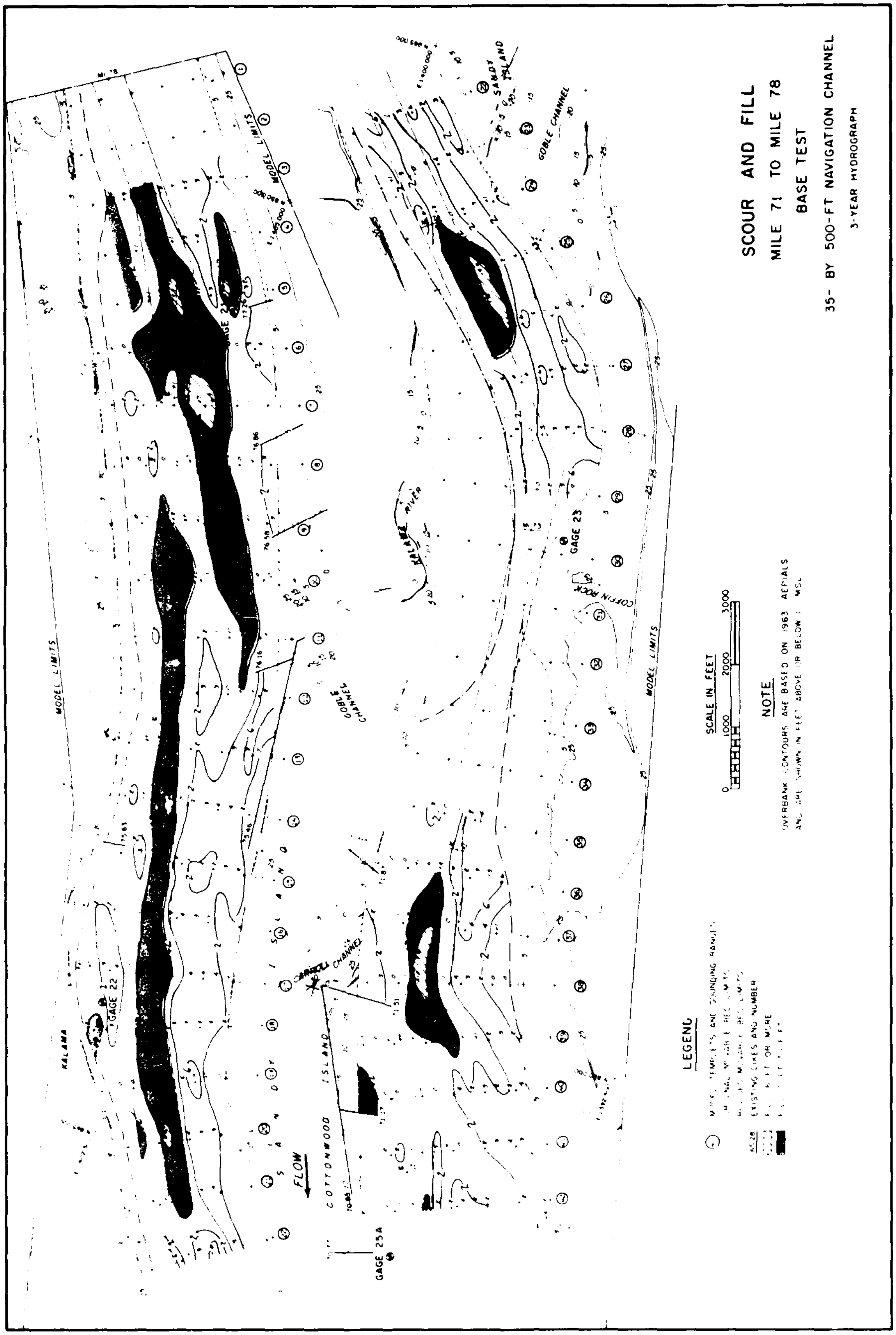
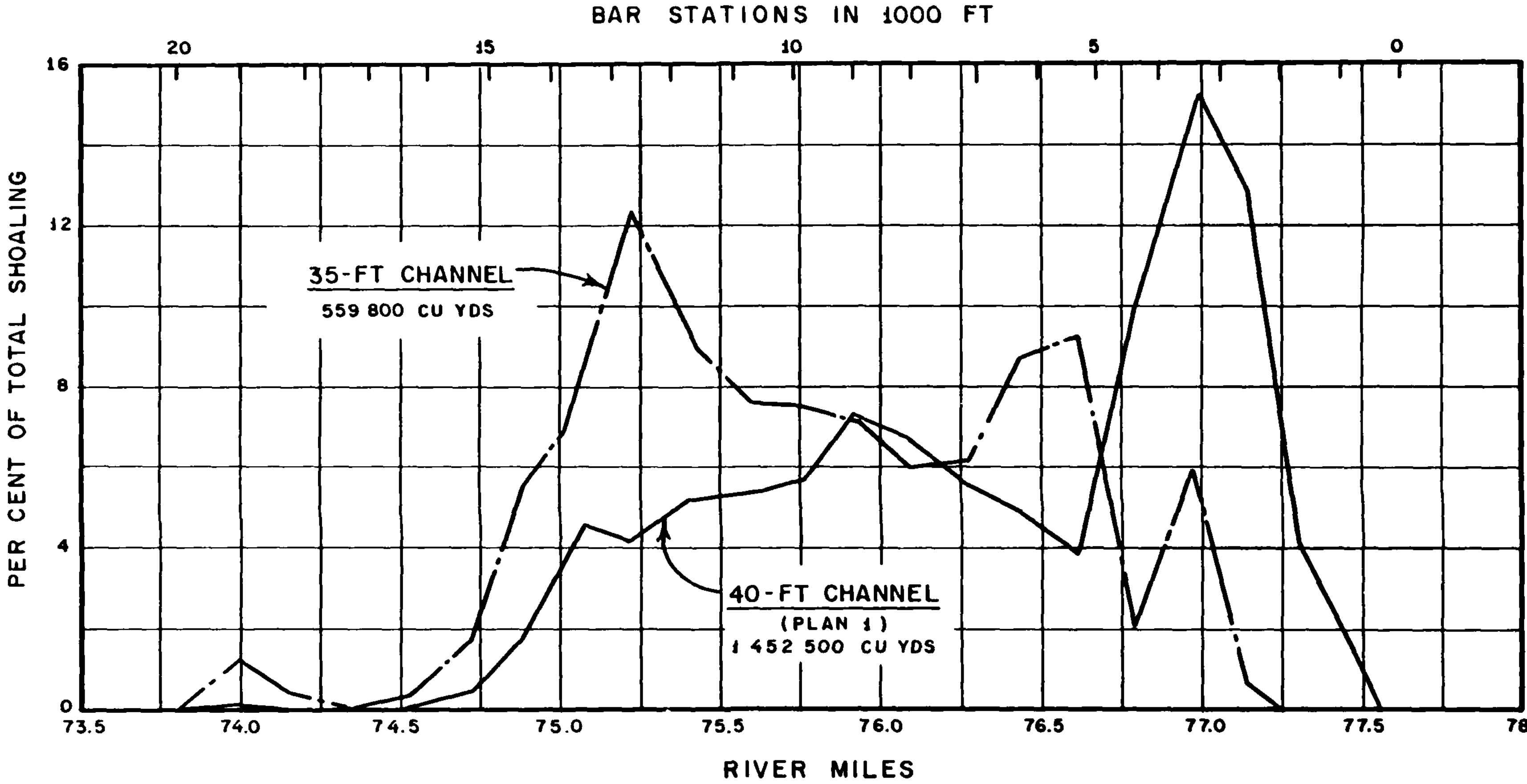
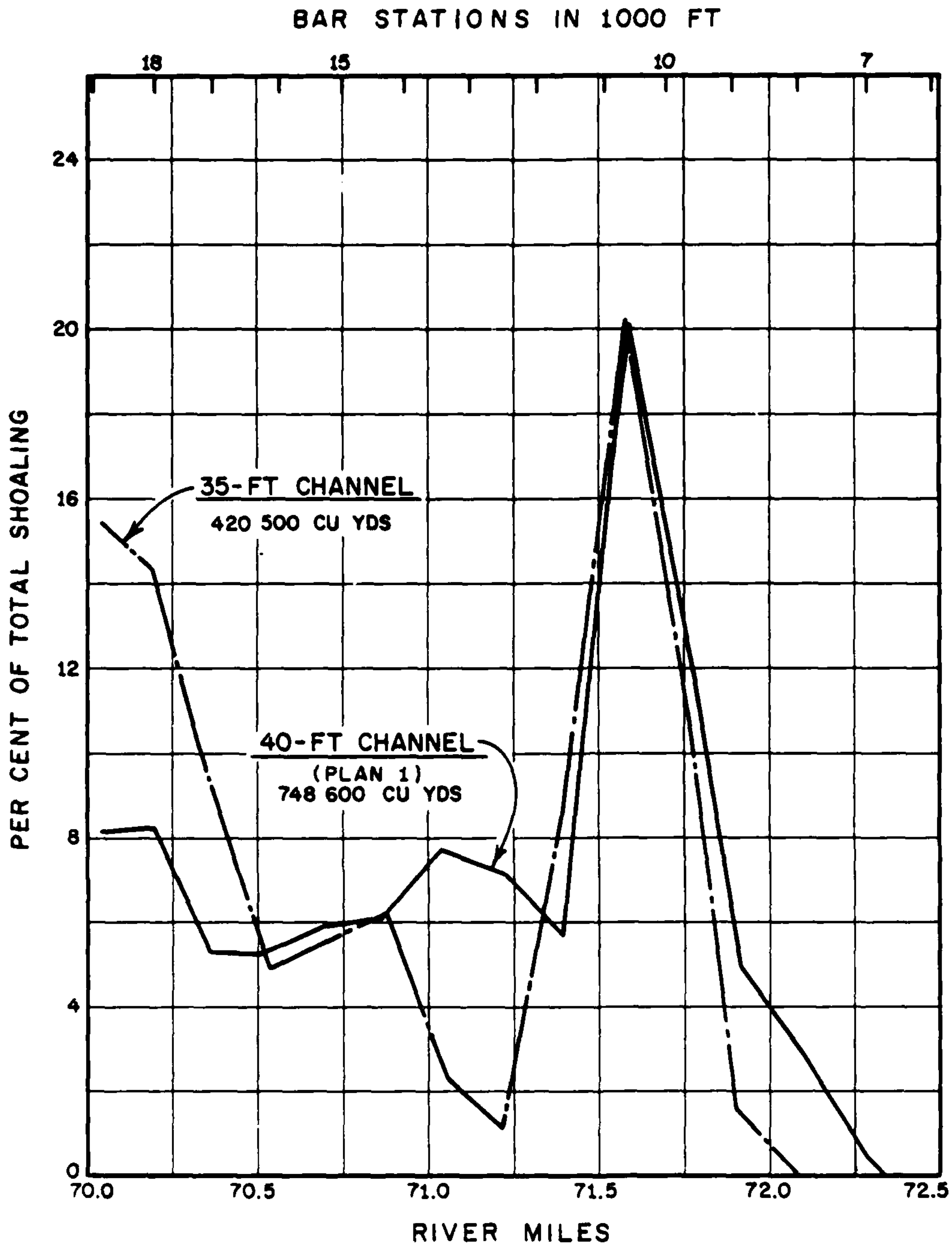

SCOUR AND FILL
MILE 64 TO MILE 71
BASE TEST
35- BY 500-FT NAVIGATION CHANNEL
3-YEAR HYDROGRAPH
SCALE IN FEET
0
1000
2000
3000
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
EXISTING DIKES AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
COTTONWOOD ISLAND
HOWARD ISLAND
GAGE 25A
GAGE 26-A
GAGE 28
GAGE 30
MODEL LIMITS
LONGVIEW, WASH
RAINIER, ORE
LOG STORAGE AREA
FLOW

PLATE 22

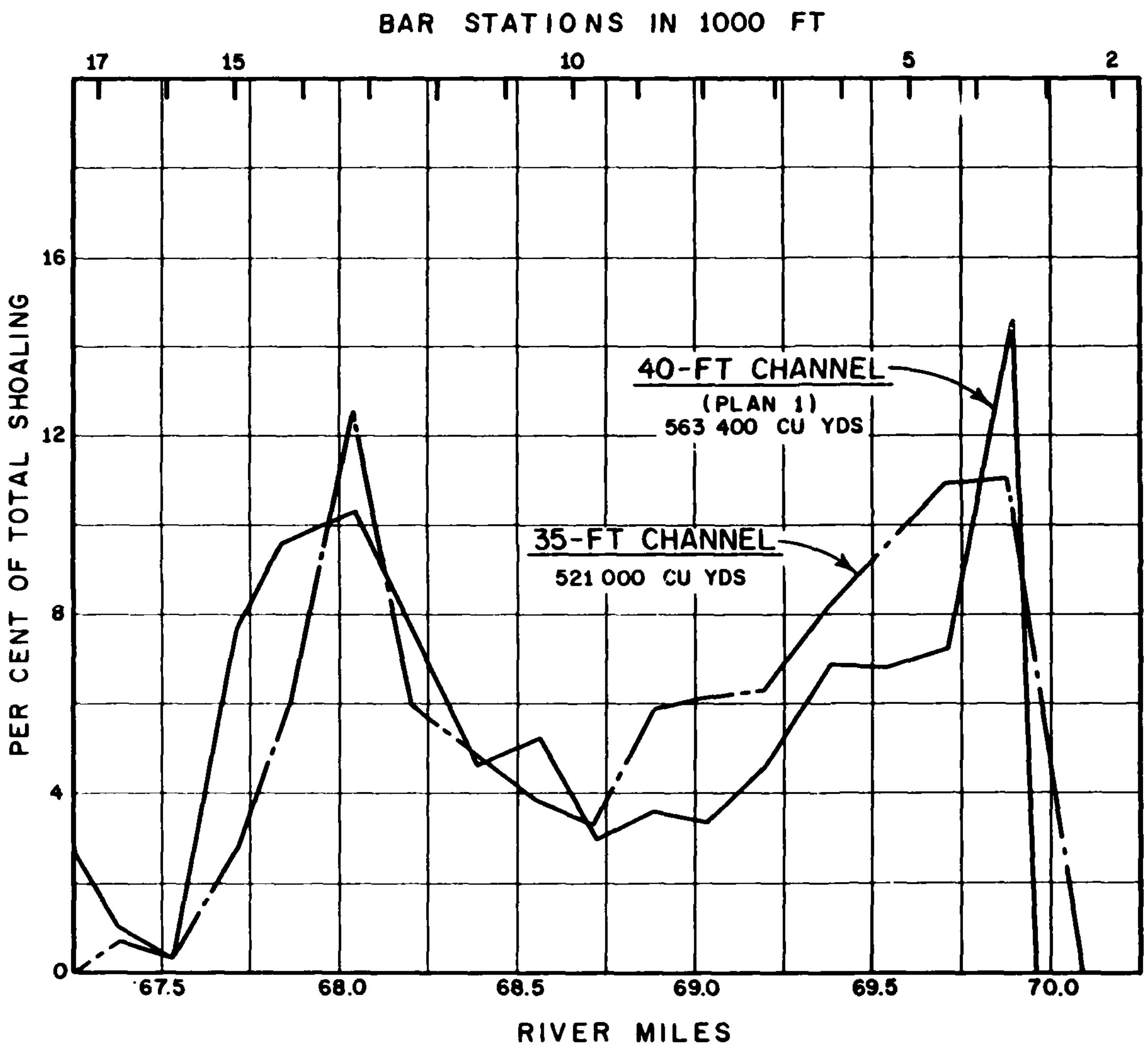

SCOUR AND FILL
MILE 71 TO MILE 78
BASE TEST
35- BY 500-FT NAVIGATION CHANNEL
3-YEAR HYDROGRAPH
SCALE IN FEET
0
1000
2000
3000
NOTE
LEGEND
MODEL LIMITS
GOBLE CHANNEL
SANDY ISLAND
KALAMA RIVER
GAGE 23
COFFIN ROCK
GAGE 22
KALAMA
COTTONWOOD ISLAND
CARROLLS CHANNEL
FLOW
GAGE 25A
PLATE 23



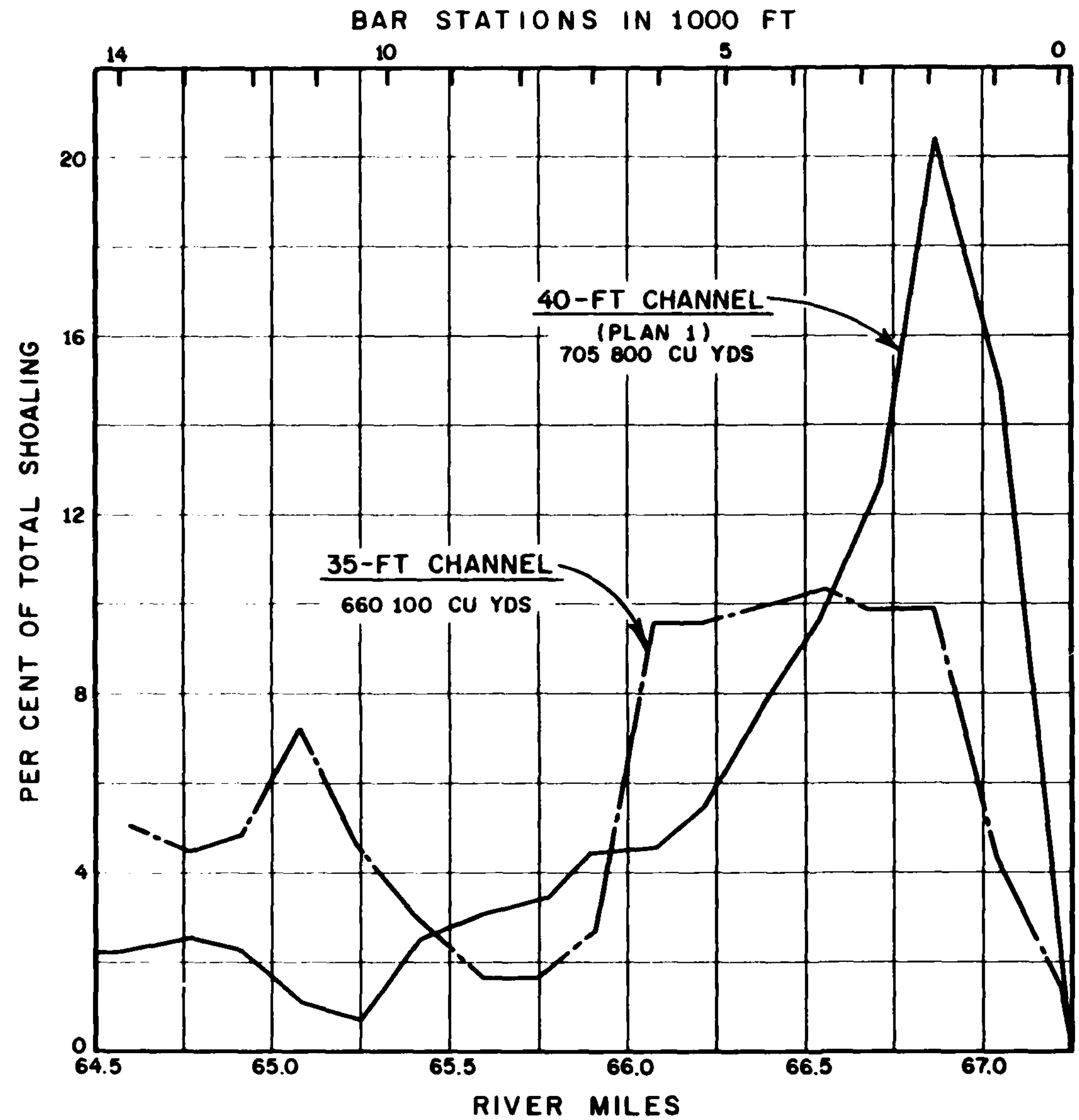
SHOALING DISTRIBUTION
KALAMA BAR
BASE TESTS



SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
BASE TESTS



SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
BASE TESTS



SHOALING DISTRIBUTION
SLAUGHTERS BAR
BASE TESTS

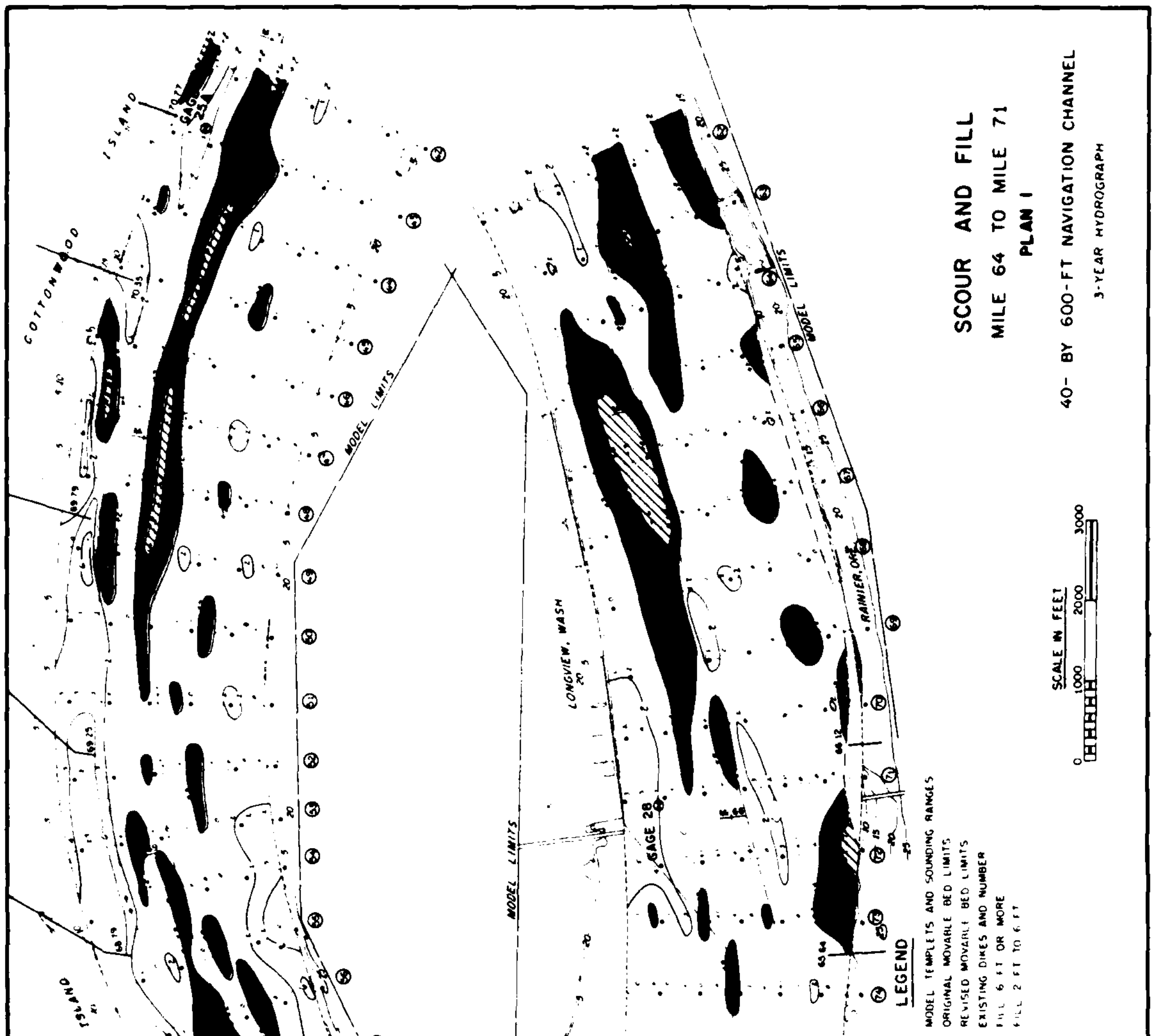

SCOUR AND FILL
MILE 64 TO MILE 71
PLAN I
40- BY 600-FT NAVIGATION CHANNEL
3-YEAR HYDROGRAPH
SCALE IN FEET
0
1000
2000
3000
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
EXISTING DIKES AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS
AND ARE SHOWN IN FEET ABOVE OR BELOW MSL
COTTONWOOD ISLAND
HOWARD ISLAND
MODEL LIMITS
LONGVIEW, WASH
RAINIER, ORE
LOG STORAGE AREA
FLOW
GAGE 26
GAGE 28
GAGE 30

PLATE 28

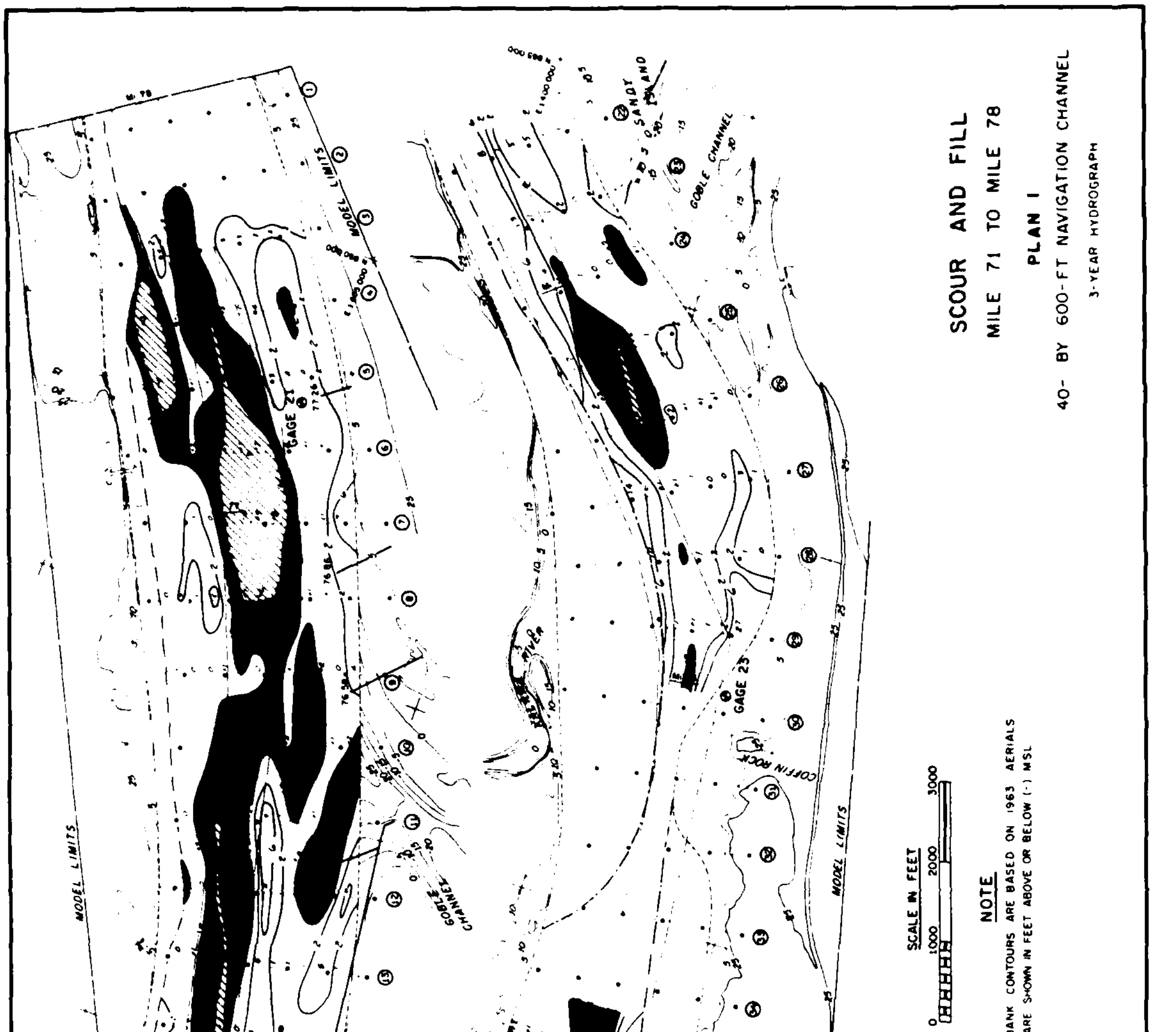

SCOUR AND FILL
MILE 71 TO MILE 78
PLAN I
40- BY 600-FT NAVIGATION CHANNEL
3-YEAR HYDROGRAPH
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS
AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
SCALE IN FEET
0
1000
2000
3000
LEGEND
EXISTING DIKES AND NUMBER
MODEL LIMITS
GAGE 21
GAGE 22
GAGE 23
GAGE 23A
KALAMA
COFFIN ROCK
GOBLE CHANNEL
CARROLL CHANNEL
COTTONWOOD ISLAND
FLOW

PLATE 29

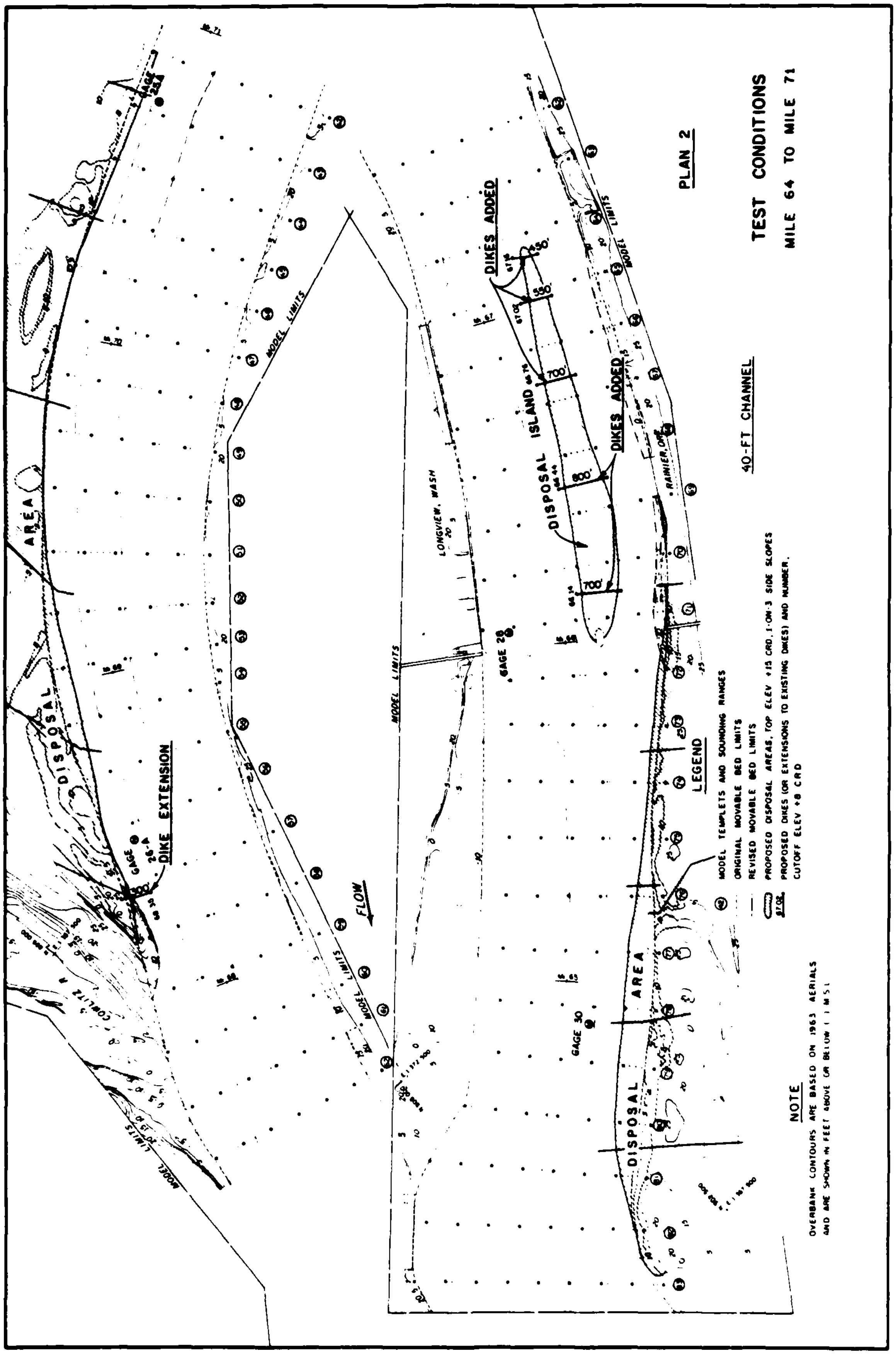
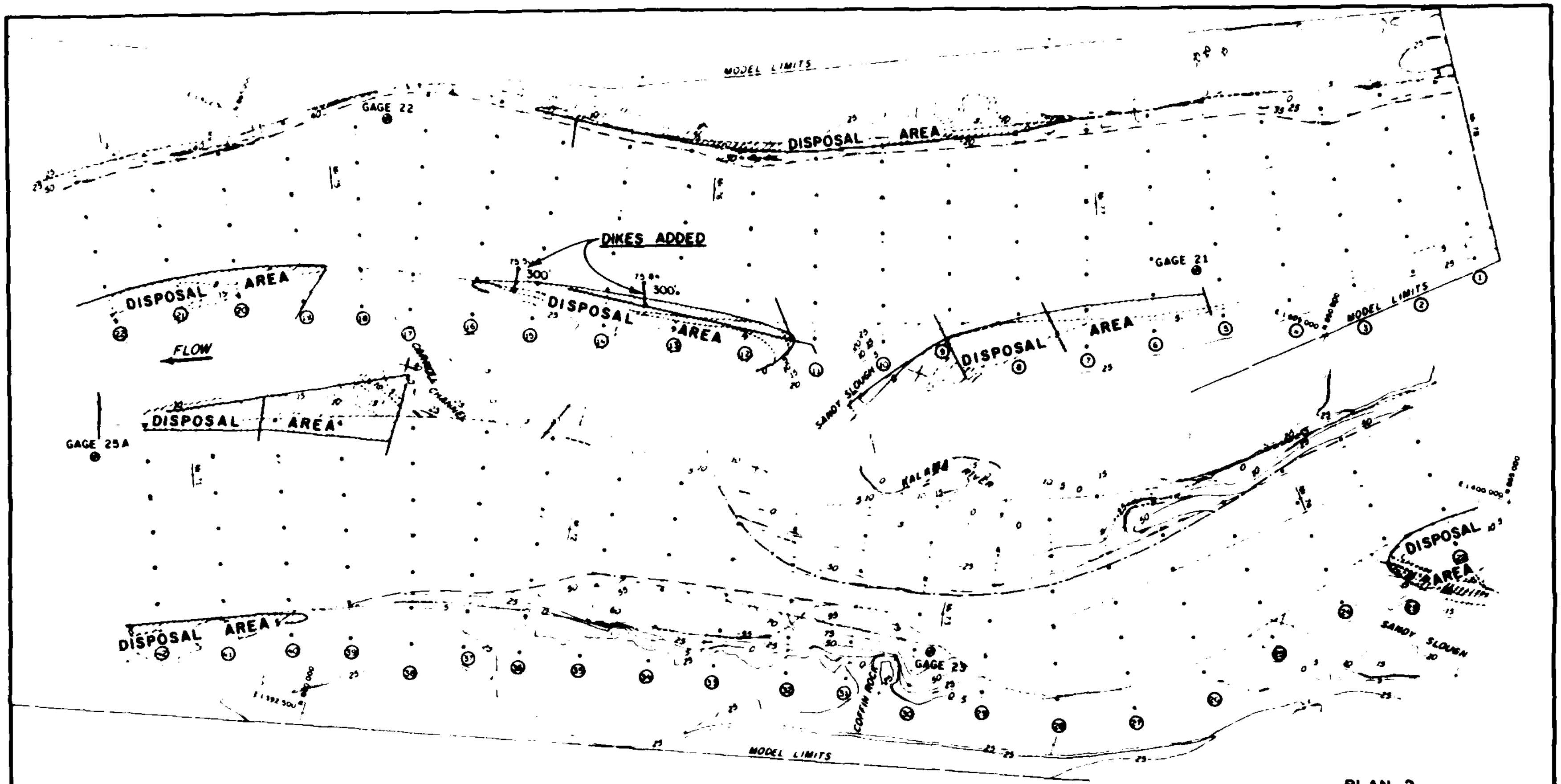

TEST CONDITIONS
MILE 64 TO MILE 71
PLAN 2
40-FT CHANNEL
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER.
CUTOFF ELEV +8 CRD
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS
AND ARE SHOWN IN FEET ABOVE OR BELOW (I M S L
DIKES ADDED
DIKES ADDED
DIKE EXTENSION
DISPOSAL ISLAND
DISPOSAL AREA
DISPOSAL AREA
DISPOSAL AREA
MODEL LIMITS
FLOW
LONGVIEW, WASH
RAINIER, ORE
COWLITZ R
GAGE 28
GAGE 30
GAGE 26-A
650'
550'
700'
600'
700'
300'

PLATE 30



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
- PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD

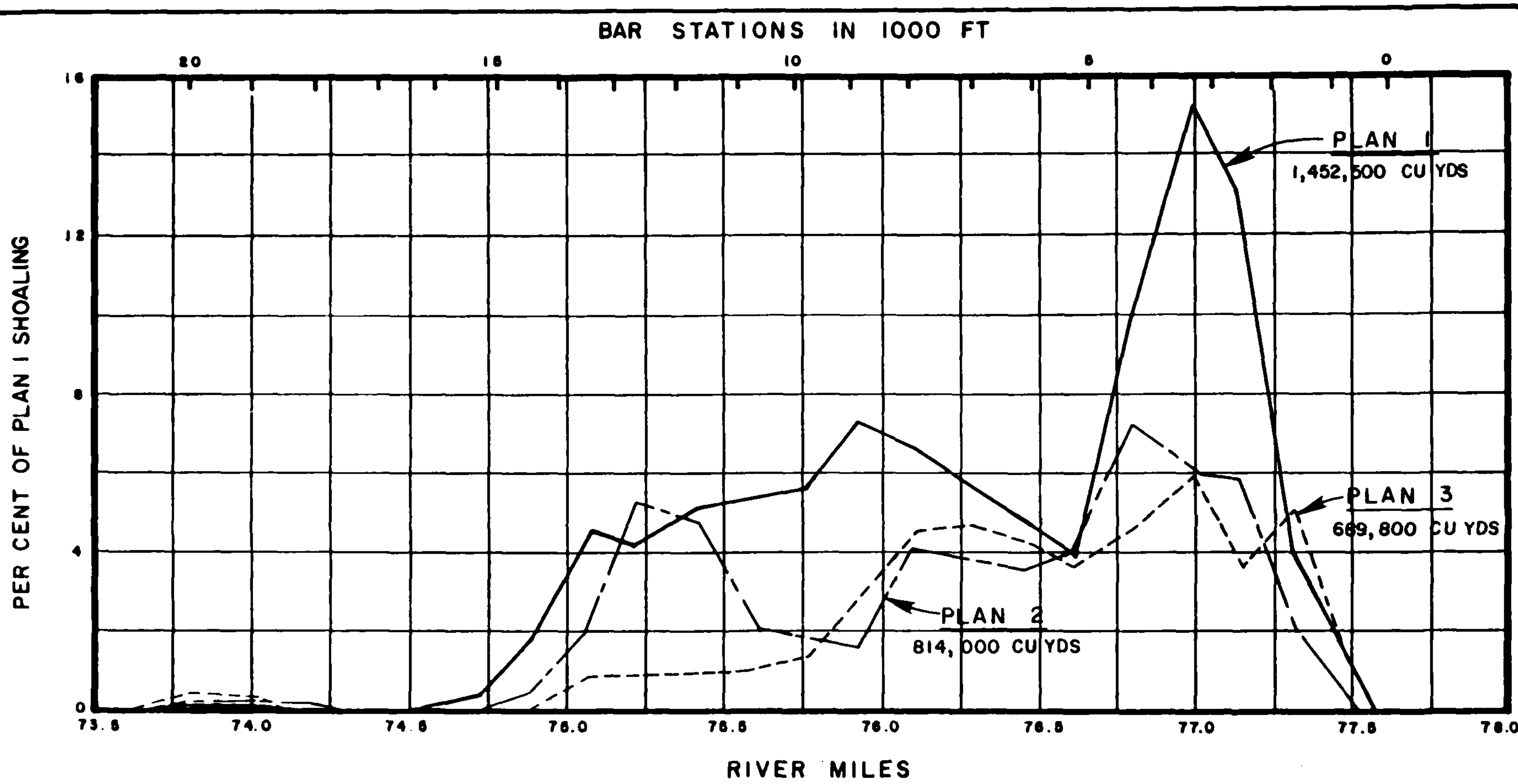
NOTE

OVERBANK CONTOURS ARE BASED ON 1983 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL

PLAN 2

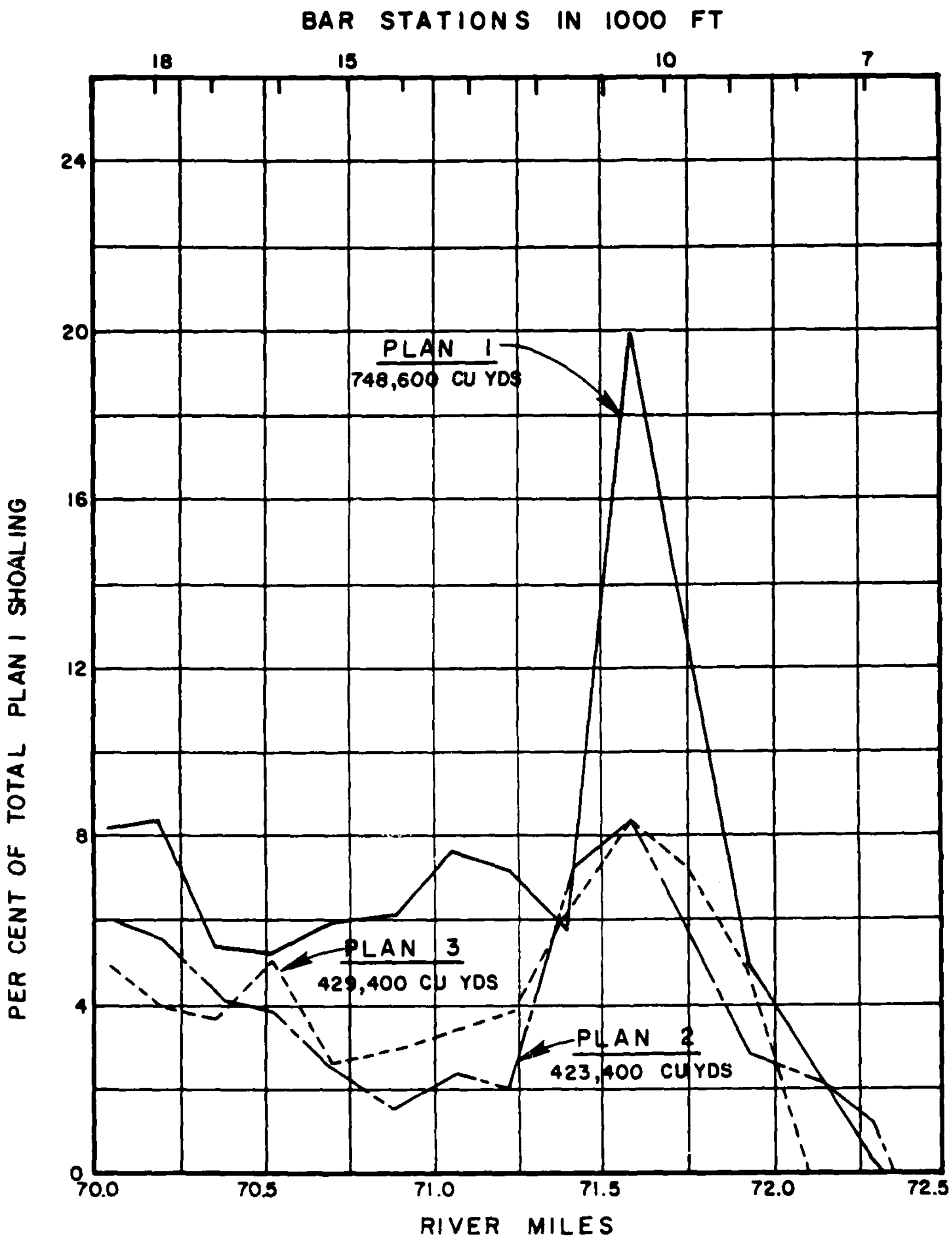
40-FT CHANNEL

TEST CONDITIONS
MILE 71 TO MILE 78



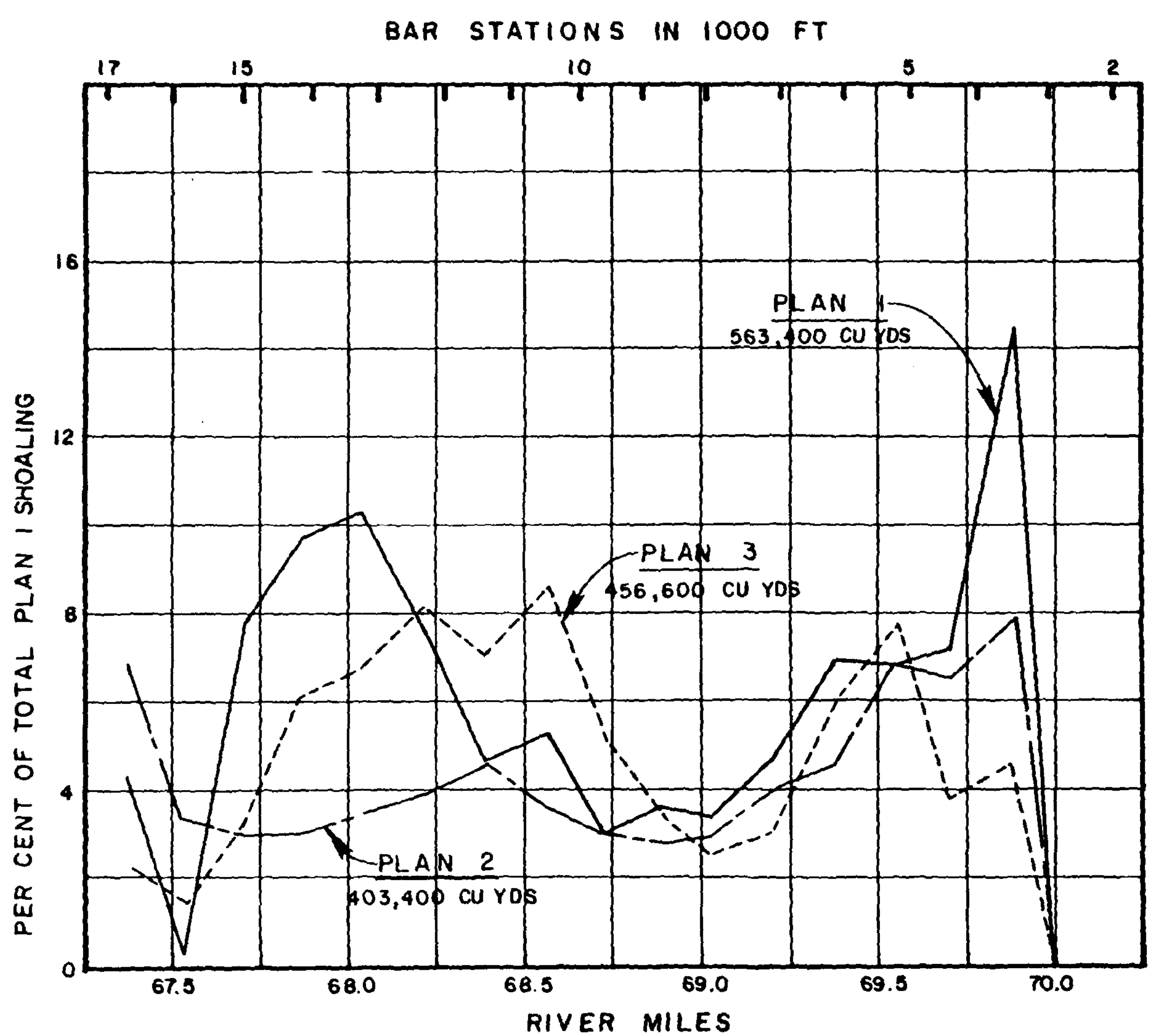
SHOALING DISTRIBUTION
KALAMA BAR
PLANS 1, 2 AND 3

40-FT CHANNEL



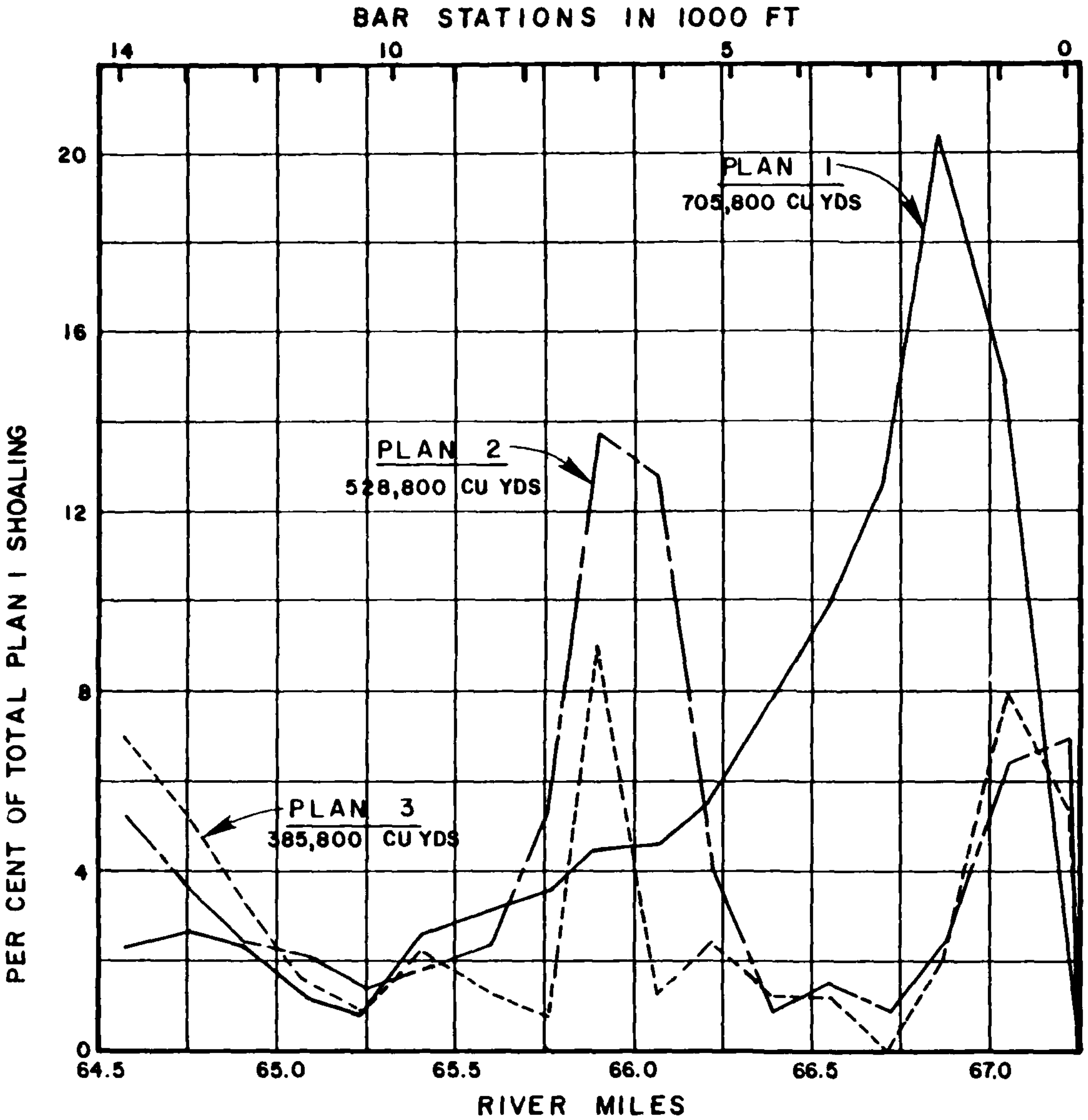
40-FT CHANNEL

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1, 2 AND 3



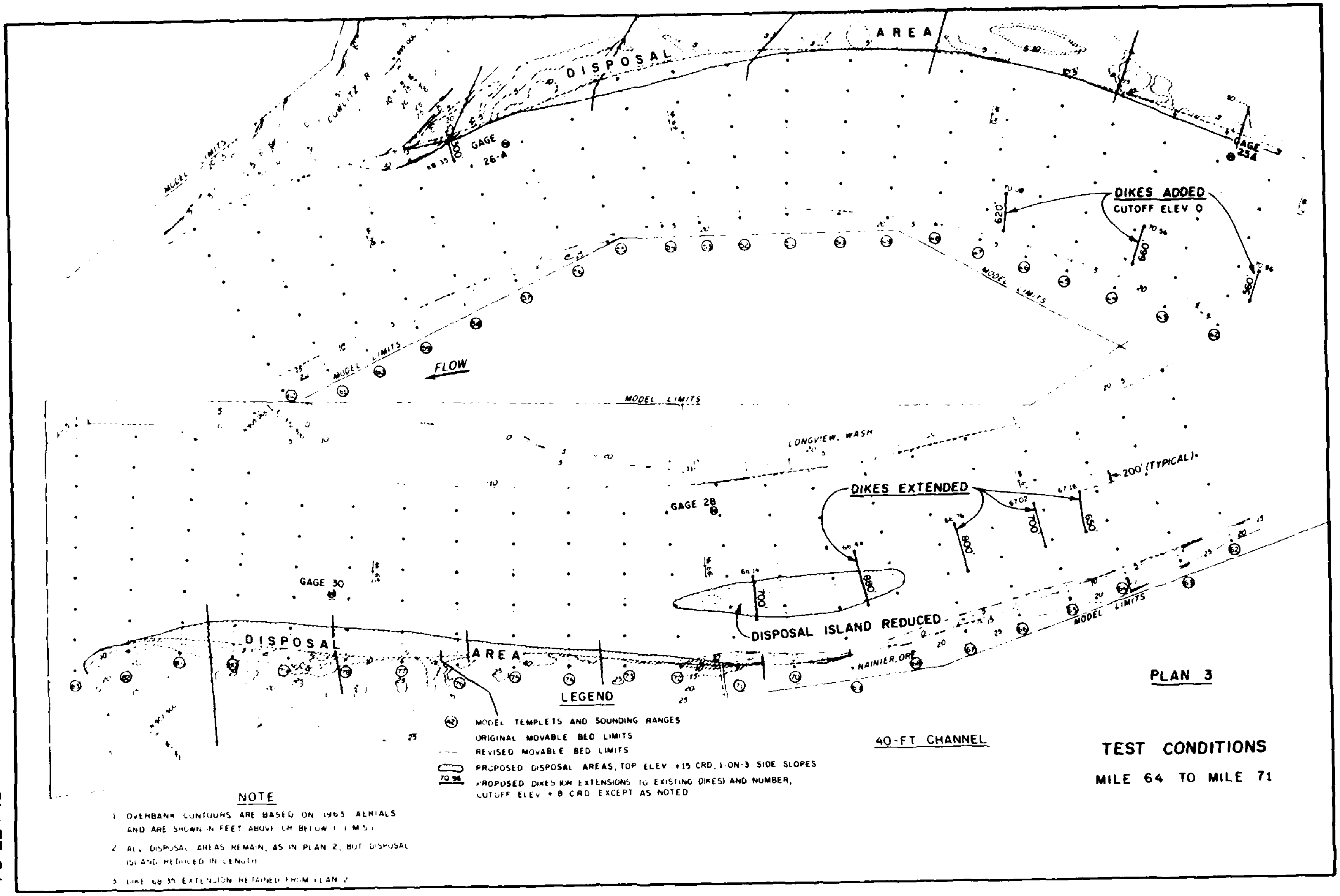
40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS 1, 2 AND 3



40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS 1, 2 AND 3


PLAN 3
TEST CONDITIONS
MILE 64 TO MILE 71
40-FT CHANNEL
DIKES ADDED
CUTOFF ELEV 0
DIKES EXTENDED
DISPOSAL ISLAND REDUCED
DISPOSAL AREA
GAGE 25A
GAGE 26-A
GAGE 28
GAGE 30
MODEL LIMITS
FLOW
LONGVIEW, WASH
RAINIER, ORE
COWLITZ R
200' (TYPICAL)
620'
660'
560'
650'
700'
800'
880'
700'
300
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV + 8 CRD EXCEPT AS NOTED
NOTE
1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW L.L.M.S.L.
2. ALL DISPOSAL AREAS REMAIN AS IN PLAN 2, BUT DISPOSAL ISLAND REDUCED IN LENGTH
3. DIKE 68.35 EXTENSION RETAINED FROM PLAN 2

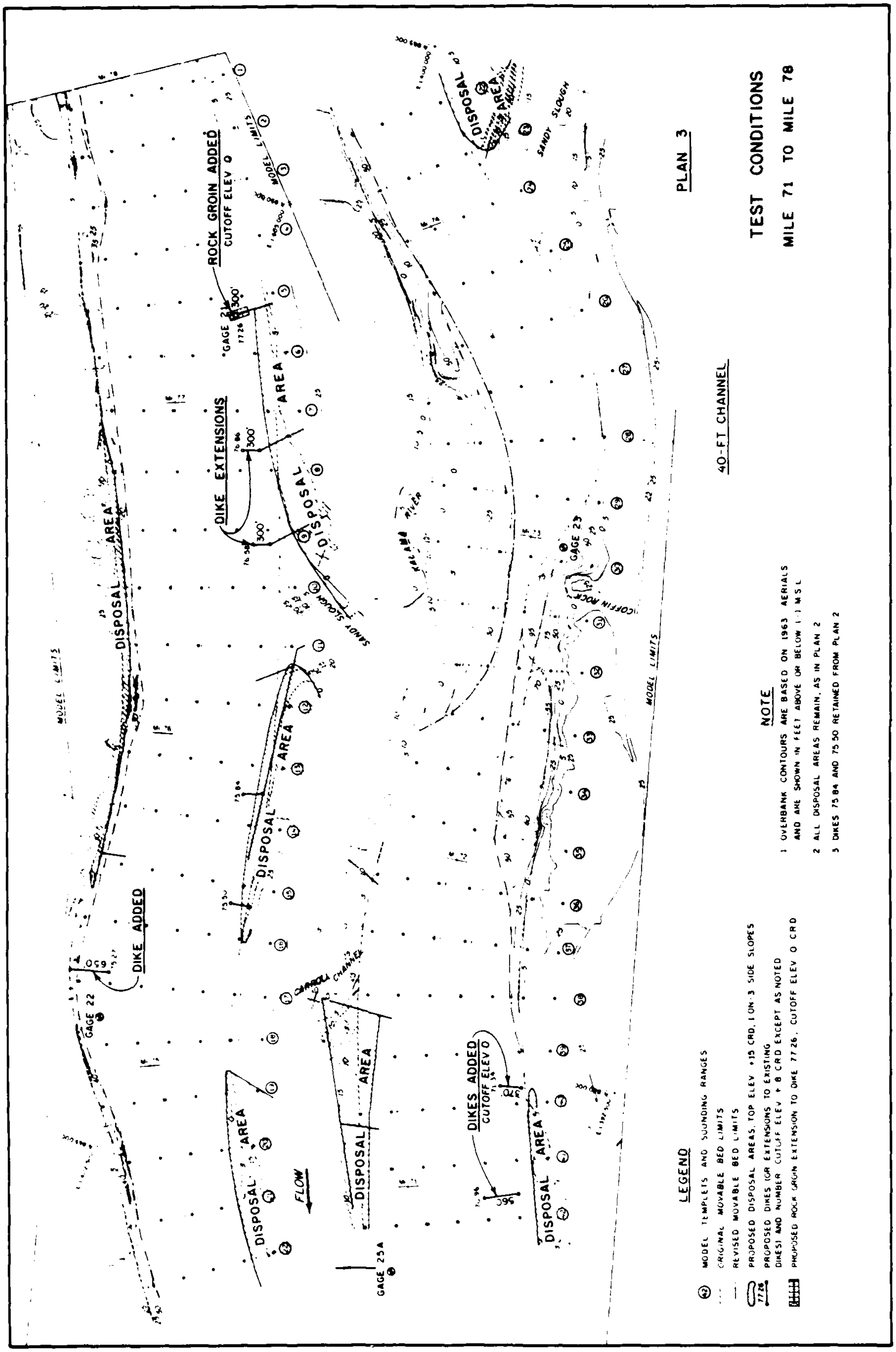

TEST CONDITIONS
MILE 71 TO MILE 78
PLAN 3
40-FT CHANNEL
ROCK GROIN ADDED
CUTOFF ELEV 0
DIKE EXTENSIONS
DIKE ADDED
DIKES ADDED
CUTOFF ELEV 0
DISPOSAL AREA
FLOW
GAGE 21
GAGE 22
GAGE 23
GAGE 25A
MODEL LIMITS
SANDY SLOUGH
KALAMA RIVER
COFFIN ROCK
CARROLLS CHANNEL
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER CUTOFF ELEV + 8 CRD EXCEPT AS NOTED
PROPOSED ROCK GROIN EXTENSION TO DIKE 7726, CUTOFF ELEV 0 CRD
NOTE
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2 ALL DISPOSAL AREAS REMAIN AS IN PLAN 2
3 DIKES 75.84 AND 75.50 RETAINED FROM PLAN 2

PLATE 37

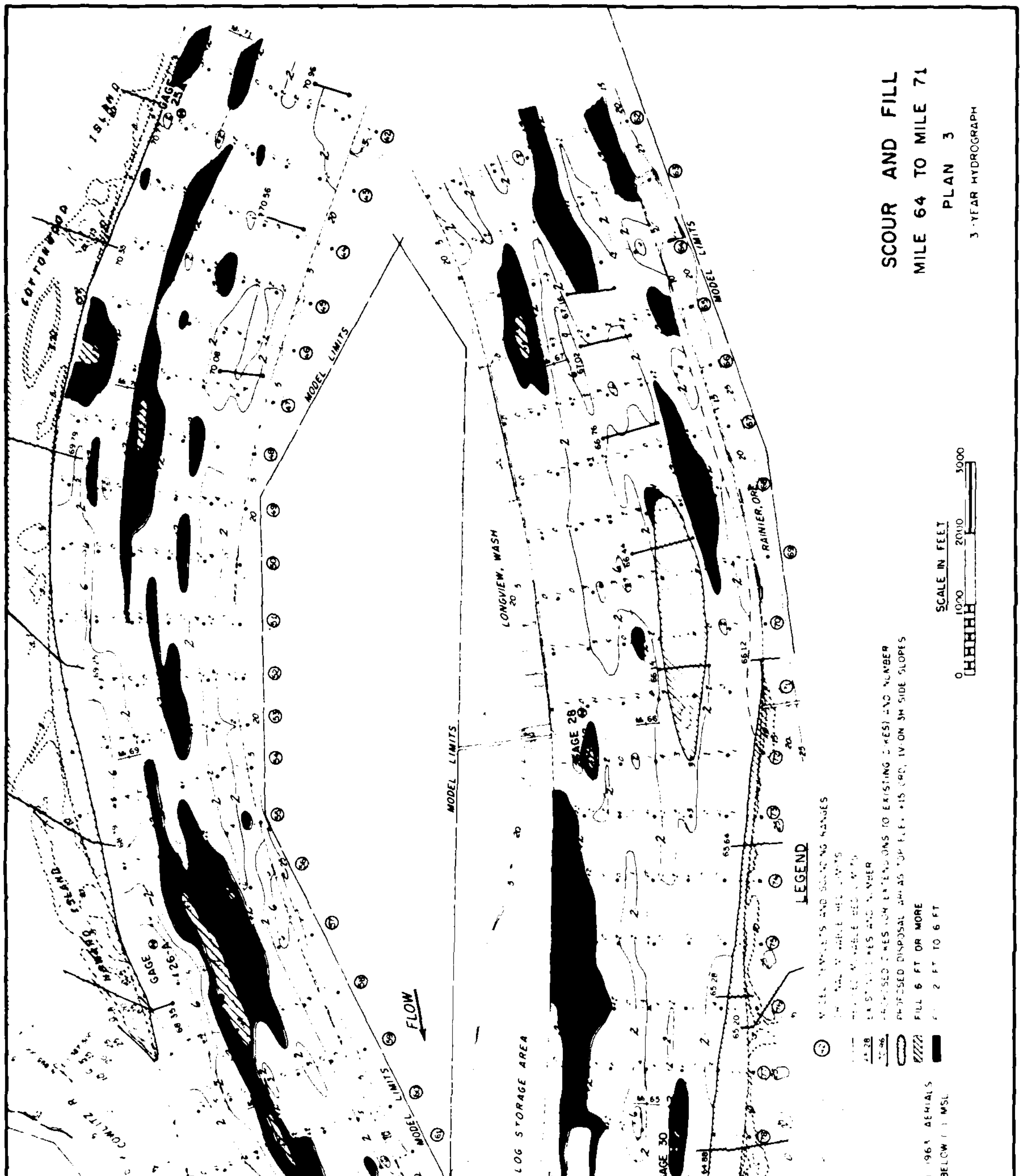
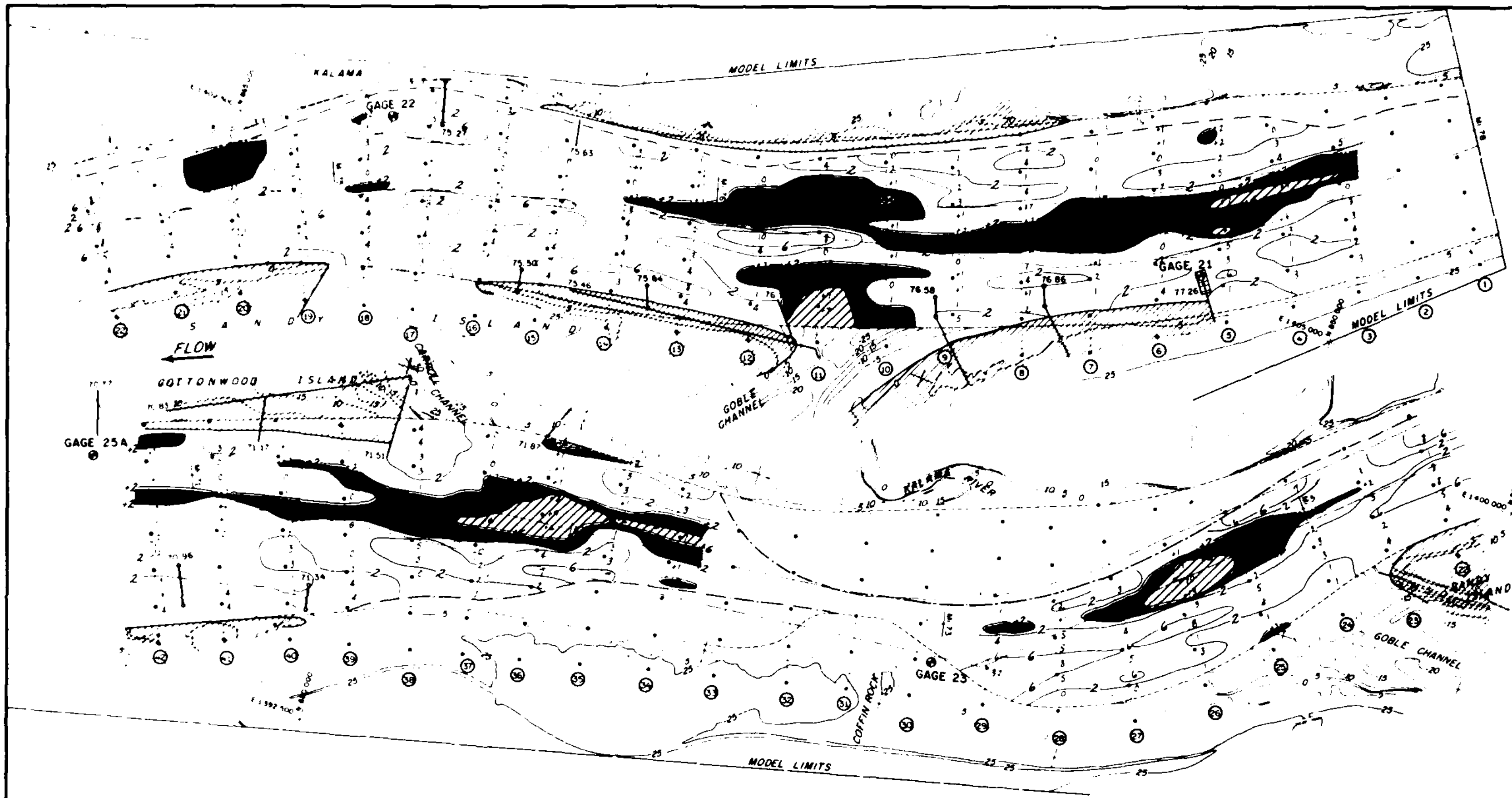

SCOUR AND FILL
MILE 64 TO MILE 71
PLAN 3
3-YEAR HYDROGRAPH
SCALE IN FEET
0
1000
2000
3000
LEGEND
FILL 6 FT OR MORE
NOTE
FLOW
MODEL LIMITS
LONGVIEW, WASH
RAINIER, ORE
LOG STORAGE AREA
GAGE 28
GAGE 30
GAGE
126-A
COTTONWOOD
ISLAND

PLATE 38



LEGEND

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] EXTENSIONS TO EXISTING DIKES AND NUMBER

PROPOSED DISPOSAL AREAS [illegible] 1V-ON-3H SIDE SLOPES

PROPOSED ROCK GROIN EXTENSION TO DIKE 77.26

FILL 6 FT OR MORE

FILL 2 FT TO 6 FT

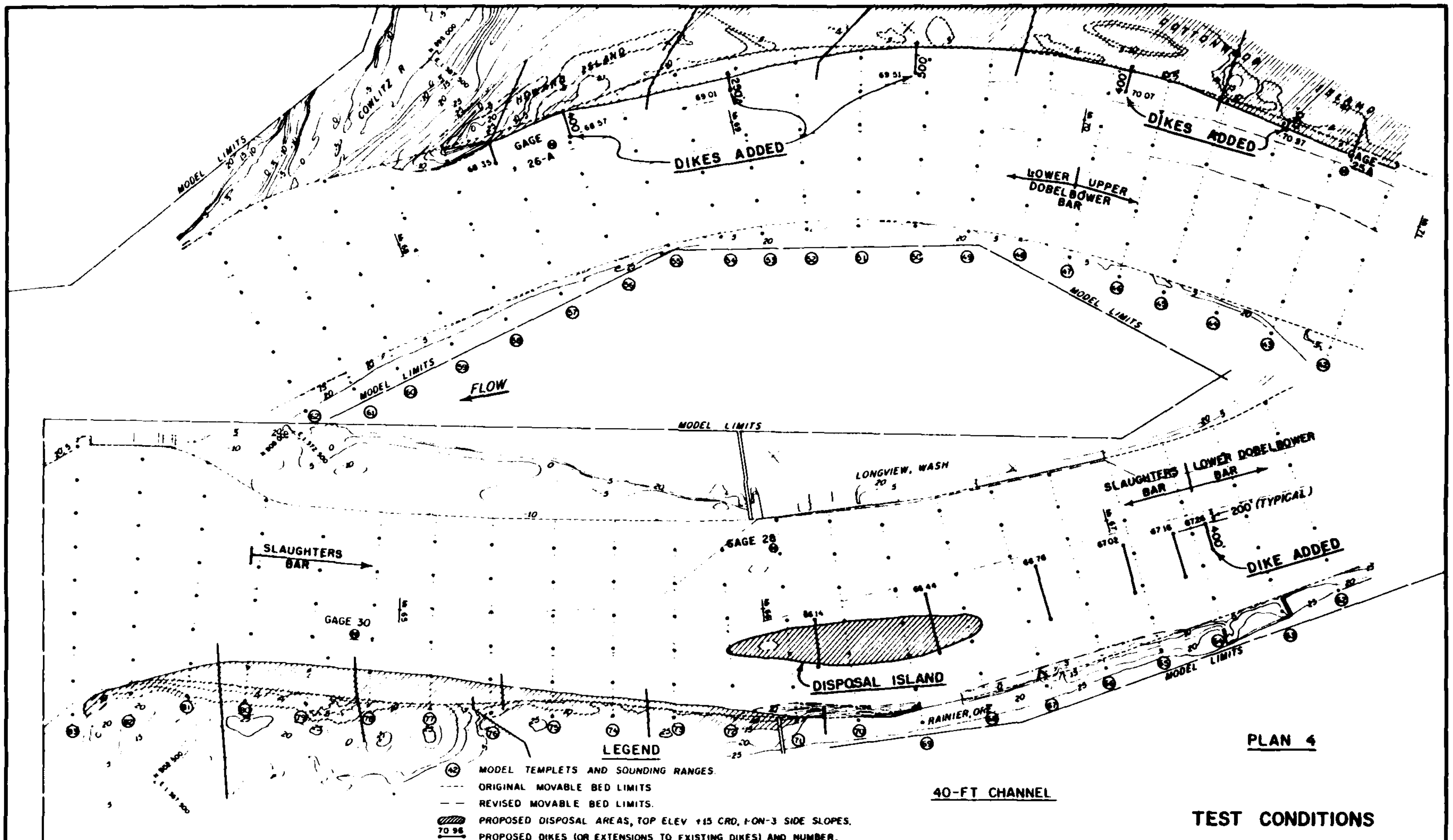
SCALE IN FEET

0 1000 2000 3000

NOTE

OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL.

SCOUR AND FILL
MILE 71 TO MILE 78
PLAN 3
3-YEAR HYDROGRAPH



NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. DISPOSAL AREAS AND DISPOSAL ISLAND REMAIN AS IN PLAN 3
3. DIKE 68 35 EXTENSION RETAINED FROM PLAN 3

TEST CONDITIONS

MILE 64 TO MILE 71

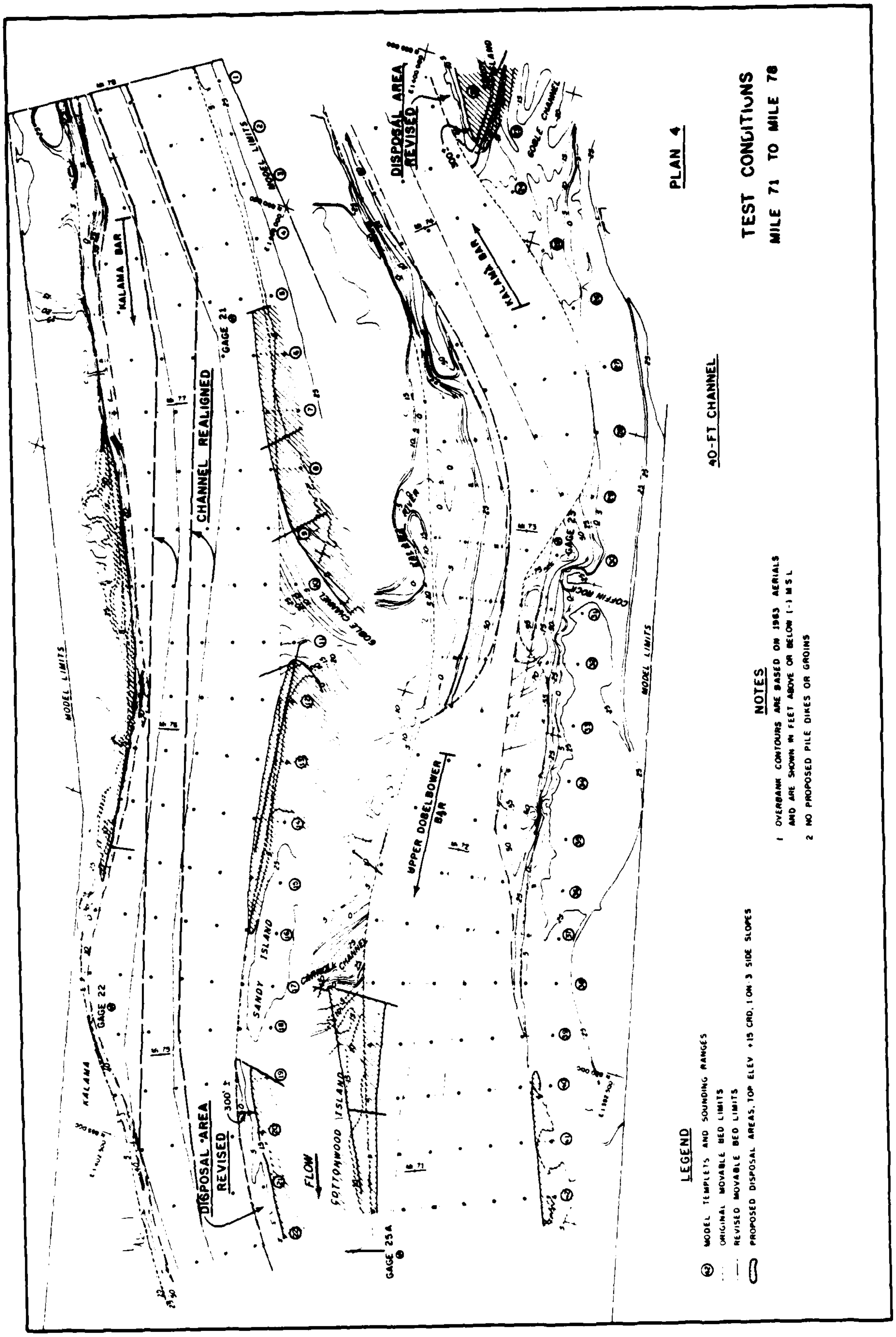
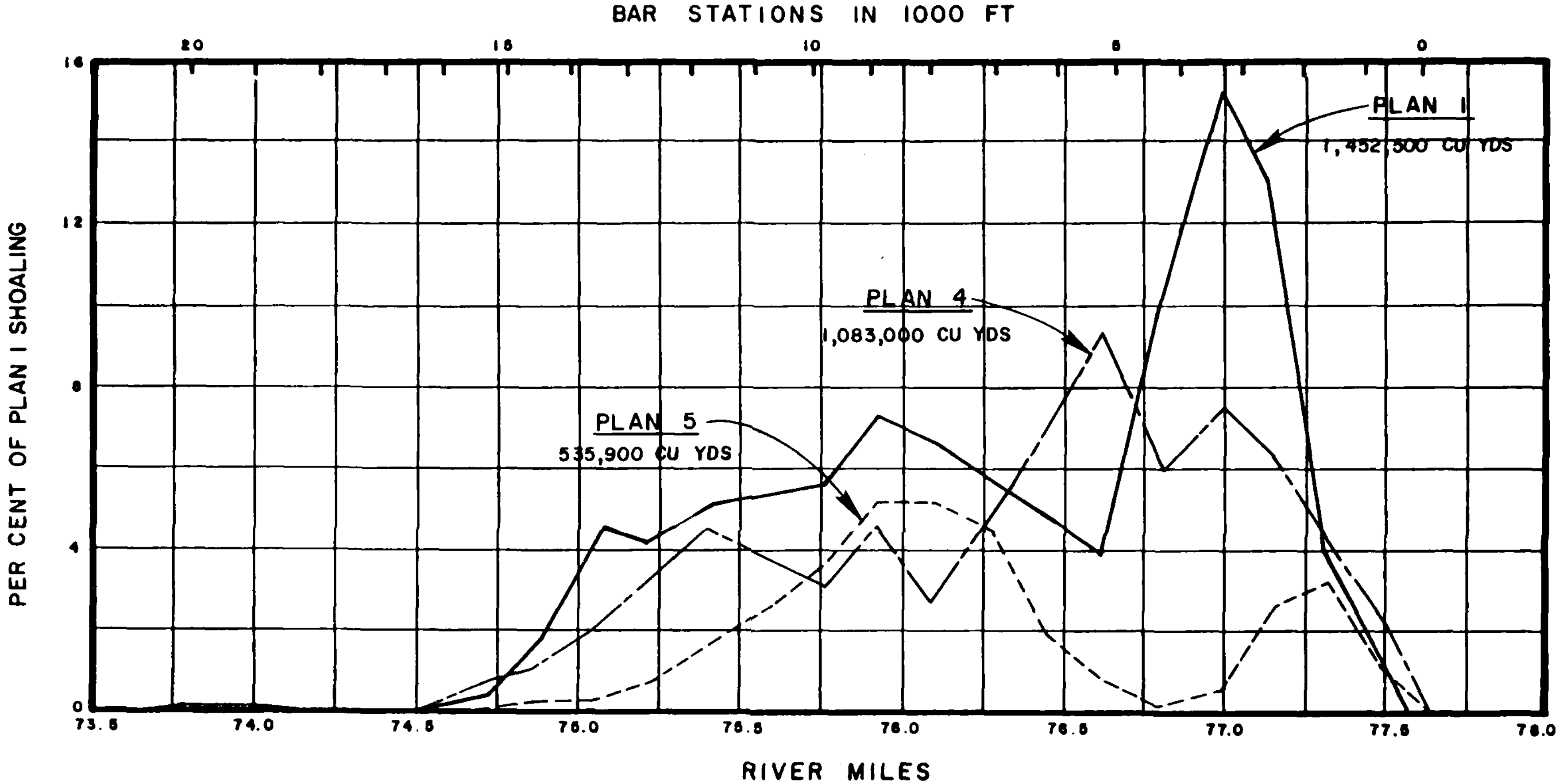
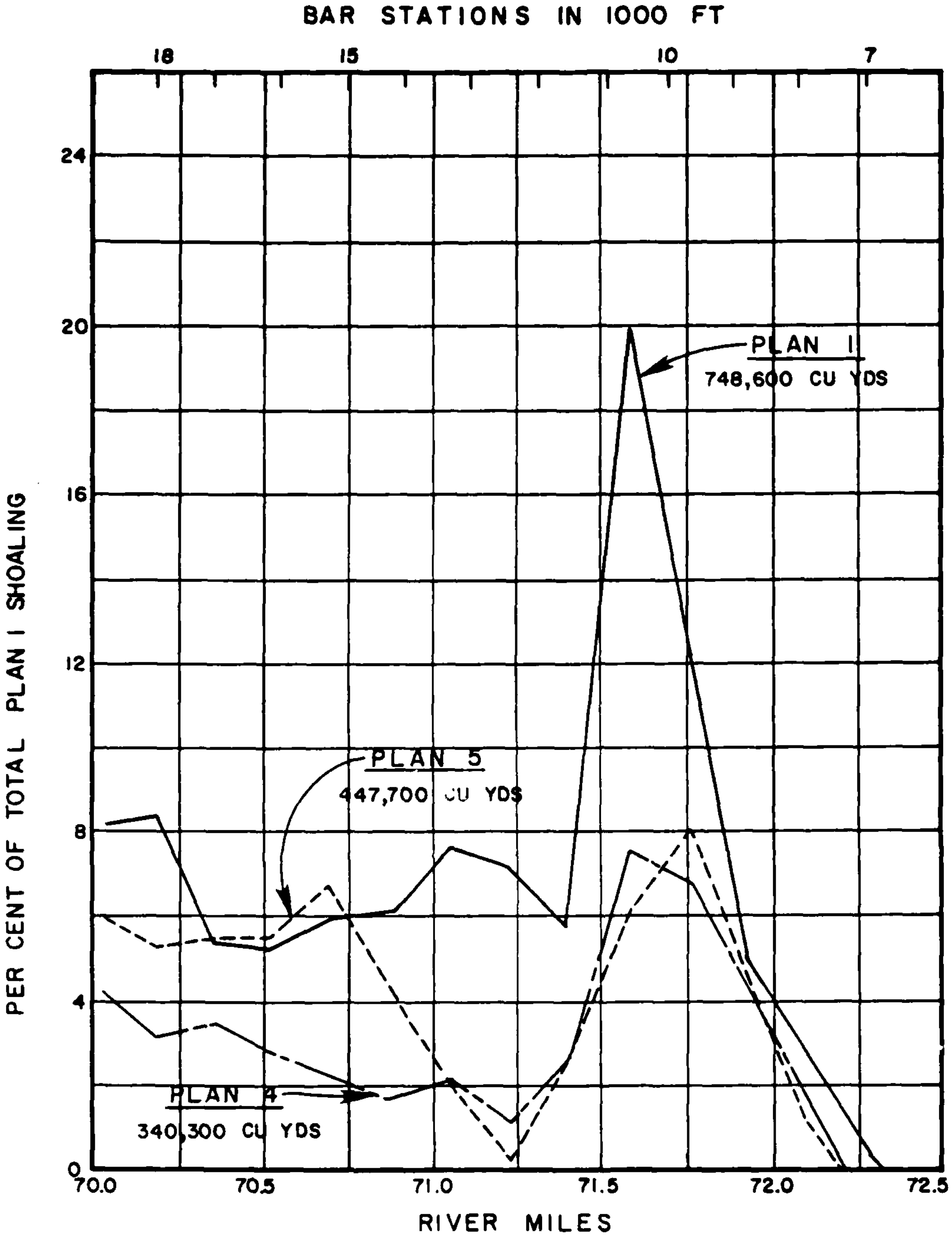

PLAN 4
TEST CONDITIONS
MILE 71 TO MILE 78
40-FT CHANNEL
CHANNEL REALIGNED
DISPOSAL AREA REVISED
DISPOSAL AREA REVISED
KALAMA BAR
KALAMA BAR
UPPER DOBELBOWER BAR
SANDY ISLAND
COTTONWOOD ISLAND
COFFIN ROCK
GOBLE CHANNEL
CARROLLS CHANNEL
KALAMA
FLOW
MODEL LIMITS
GAGE 21
GAGE 22
GAGE 23
GAGE 25A
300'±
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2 NO PROPOSED PILE DIKES OR GROINS

PLATE 41



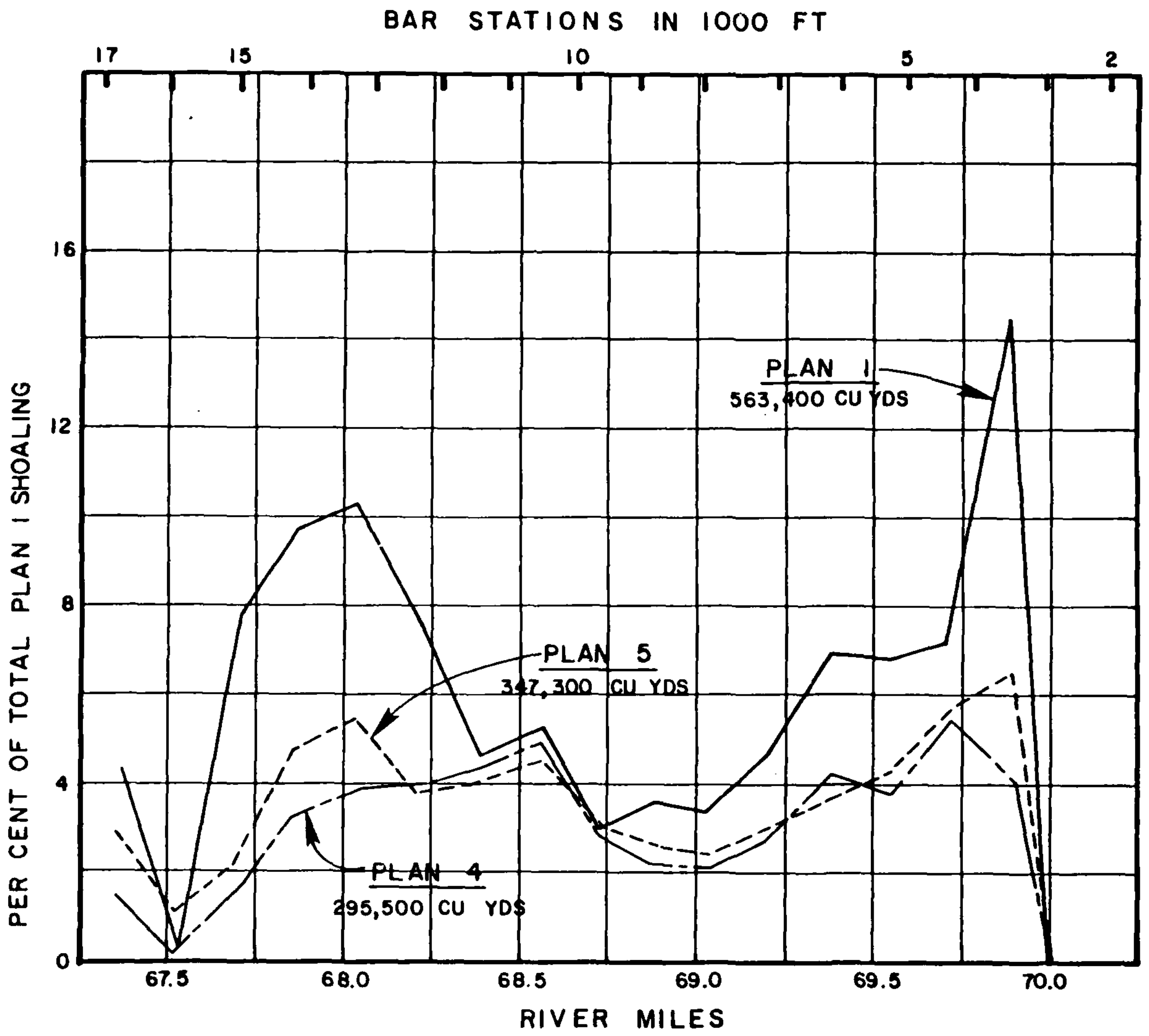
SHOALING DISTRIBUTION
KALAMA BAR
PLANS 1, 4 AND 5

40-FT CHANNEL



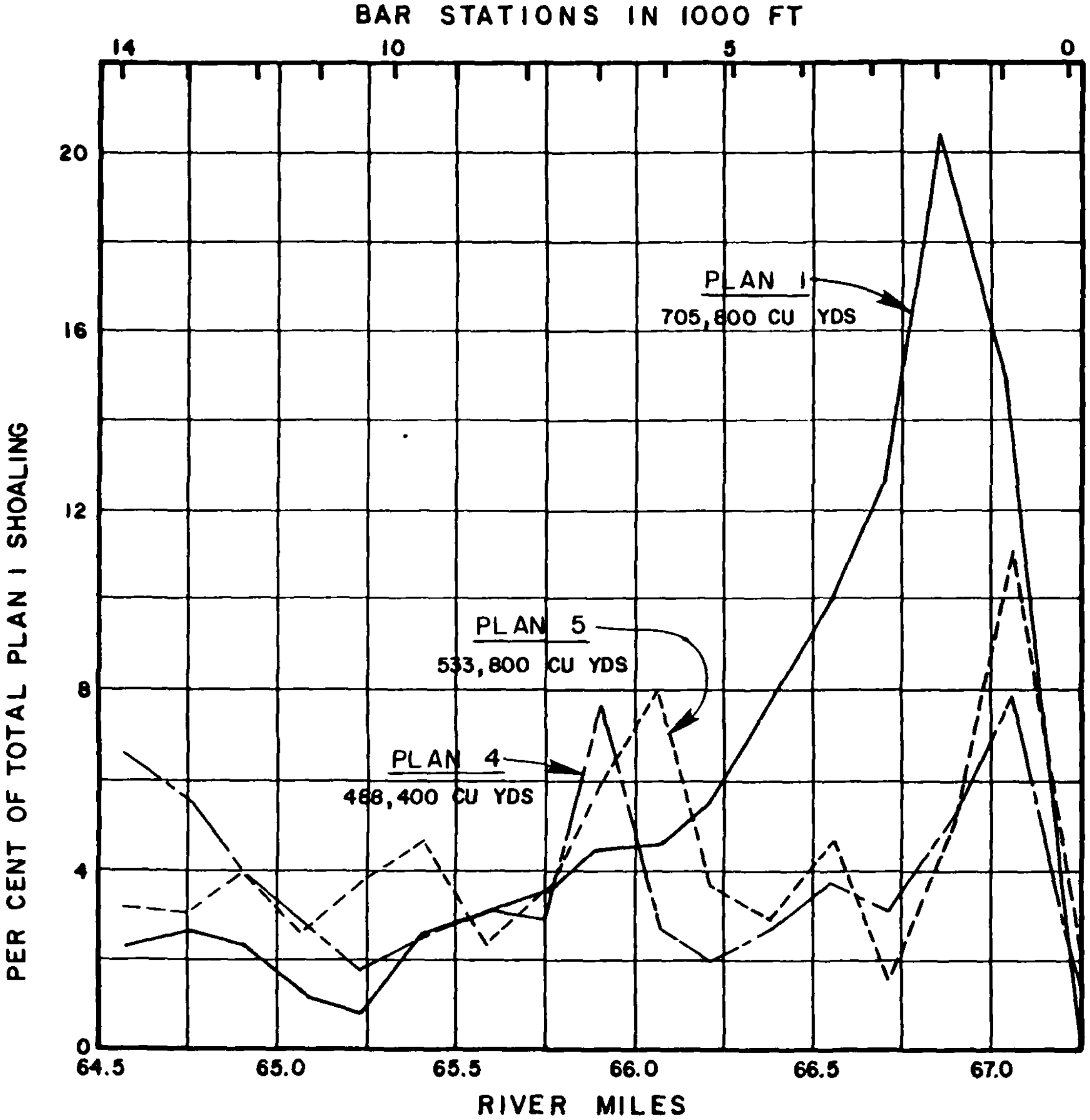
40-FT CHANNEL

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1, 4 AND 5



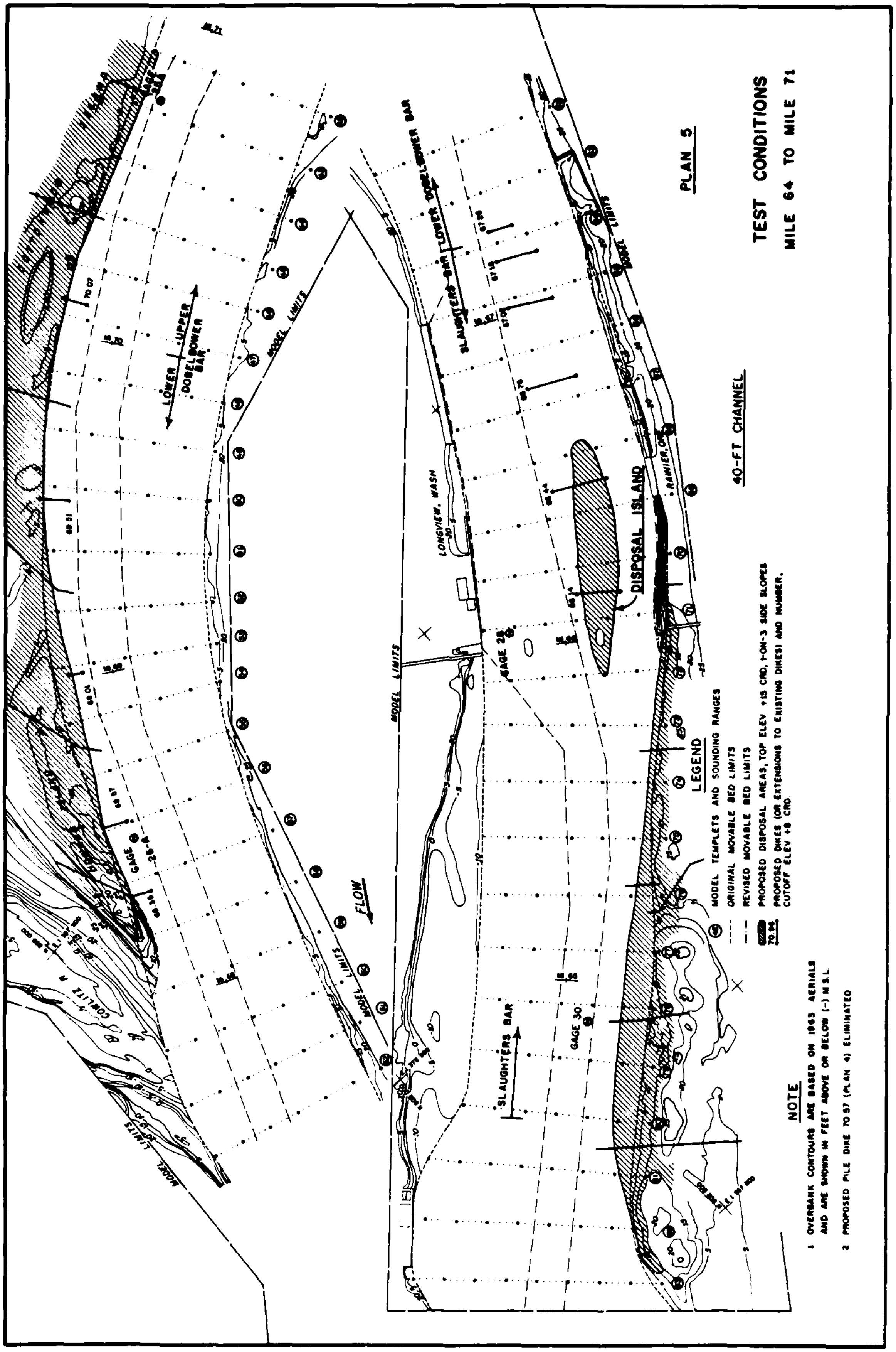
40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS 1, 4 AND 5

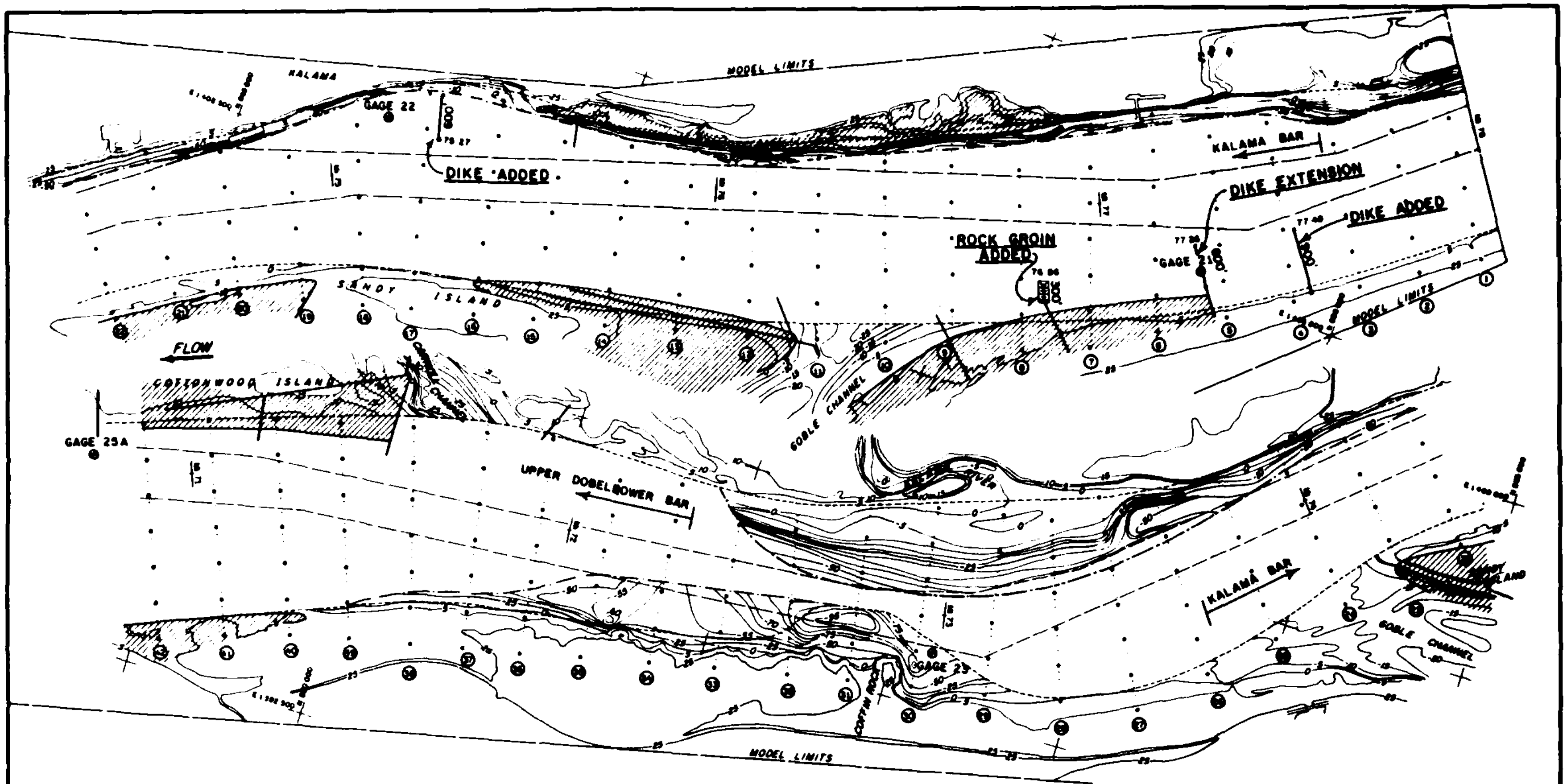


40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS 1, 4 AND 5



PLAN 5
TEST CONDITIONS
MILE 64 TO MILE 71
40-FT CHANNEL
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD
NOTE
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M.S.L.
2 PROPOSED PILE DIKE 70.57 (PLAN 4) ELIMINATED
DISPOSAL ISLAND
LONGVIEW, WASH
RAINIER, ORE
SLAUGHTERS BAR
SLAUGHTERS BAR
LOWER DOBELBOWER BAR
LOWER
UPPER
DOBELBOWER BAR
GAGE 26-A
GAGE 28
GAGE 30
FLOW
MODEL LIMITS
COWLITZ R



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
- PROPOSED ROCK GROIN, CUTOFF ELEV 0 CRD
- PROPOSED DIKES (OR EXTENSION TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD

NOTE

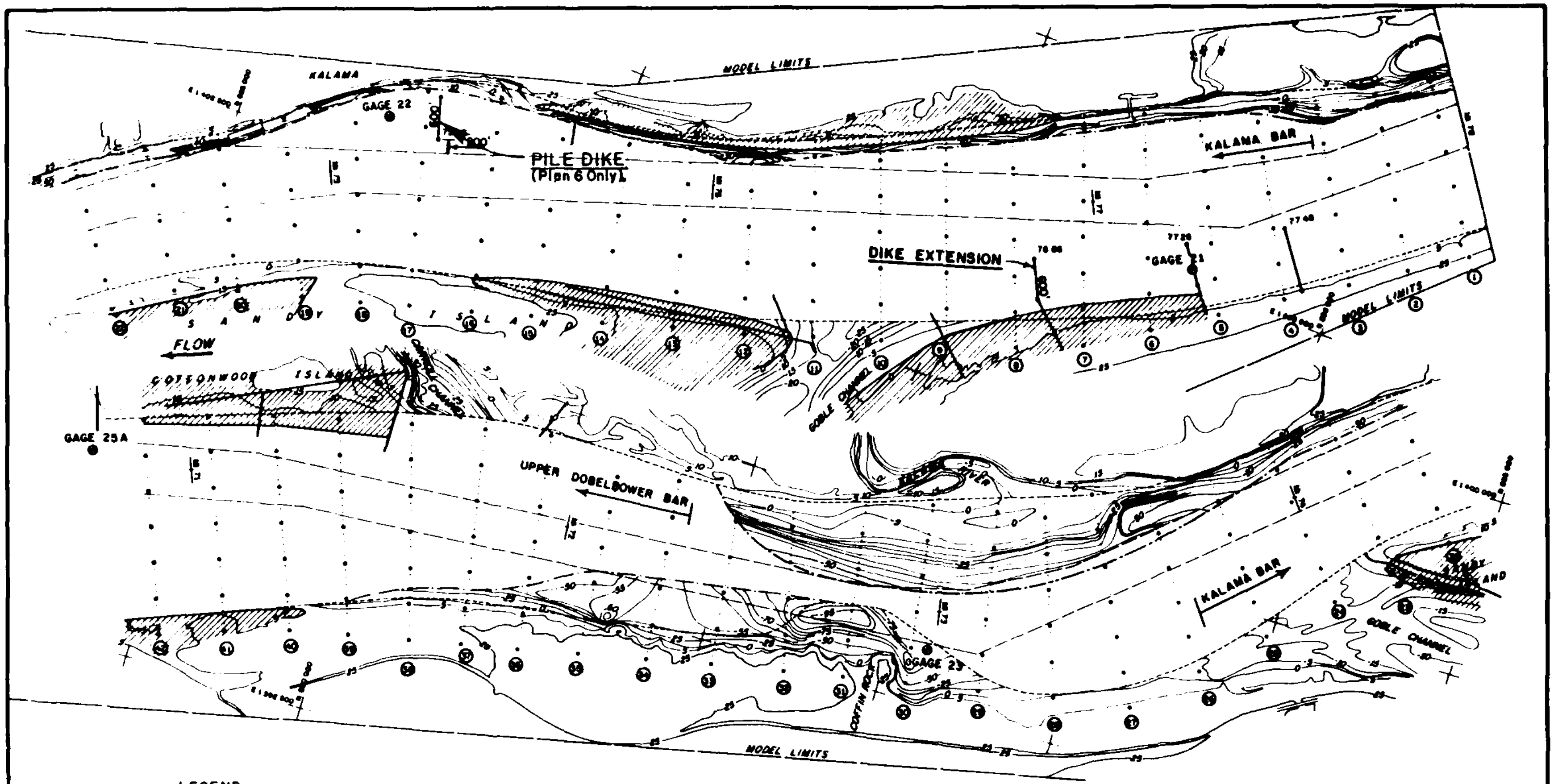
1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. PLAN 4 NAVIGATION CHANNEL REALIGNMENT RETAINED
3. DISPOSAL AREAS REMAIN AS IN PLAN 4

40-FT CHANNEL

PLAN 5

TEST CONDITIONS

MILE 71 TO MILE 78



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
- 7726 PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD

SCALE IN FEET

0 1000 2000 3000

40-FT CHANNEL

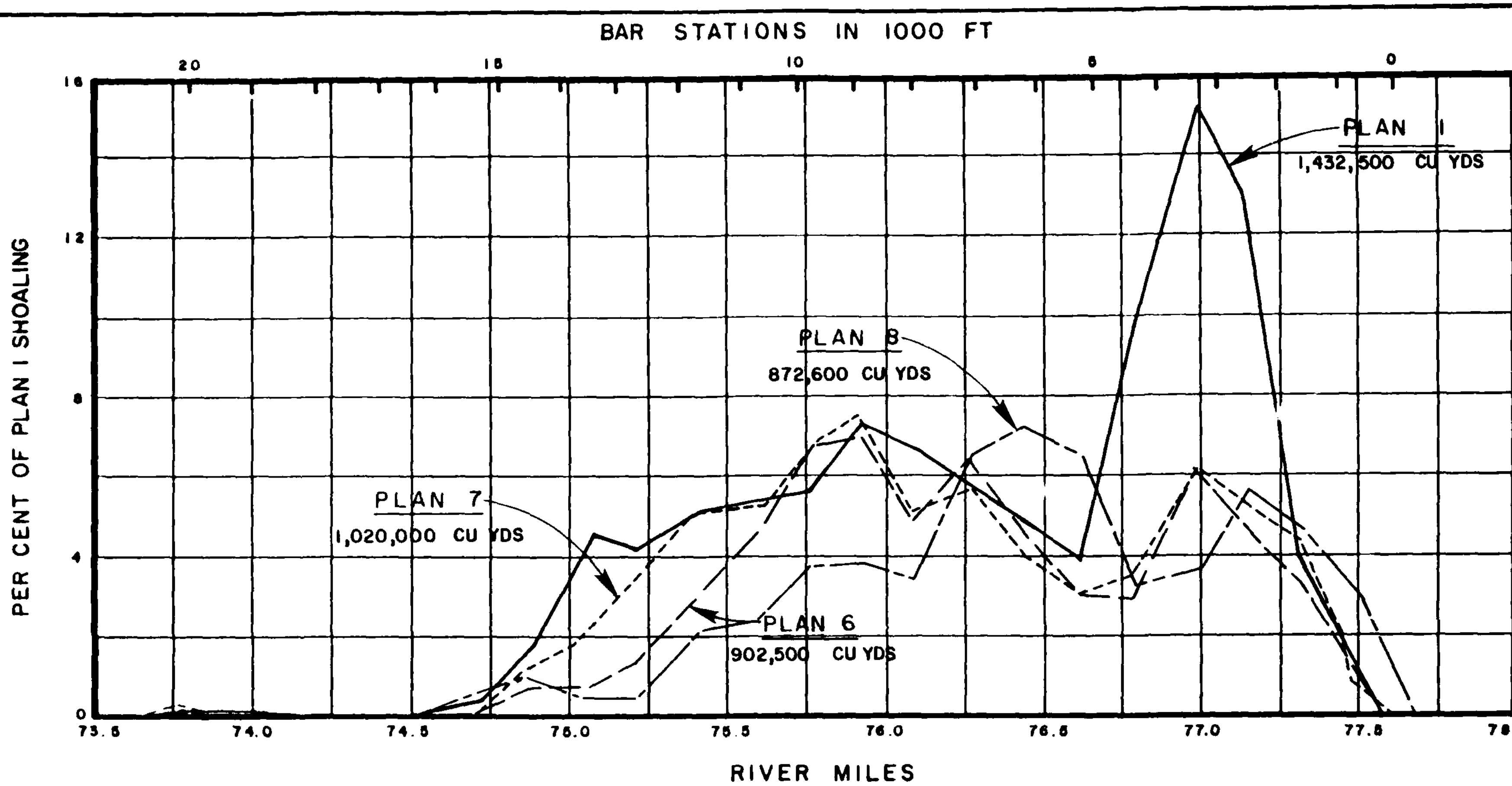
NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. PLAN 5 NAVIGATION CHANNEL ALIGNMENT RETAINED
3. DISPOSAL AREAS REMAIN AS IN PLAN 5

PLANS 6 & 7

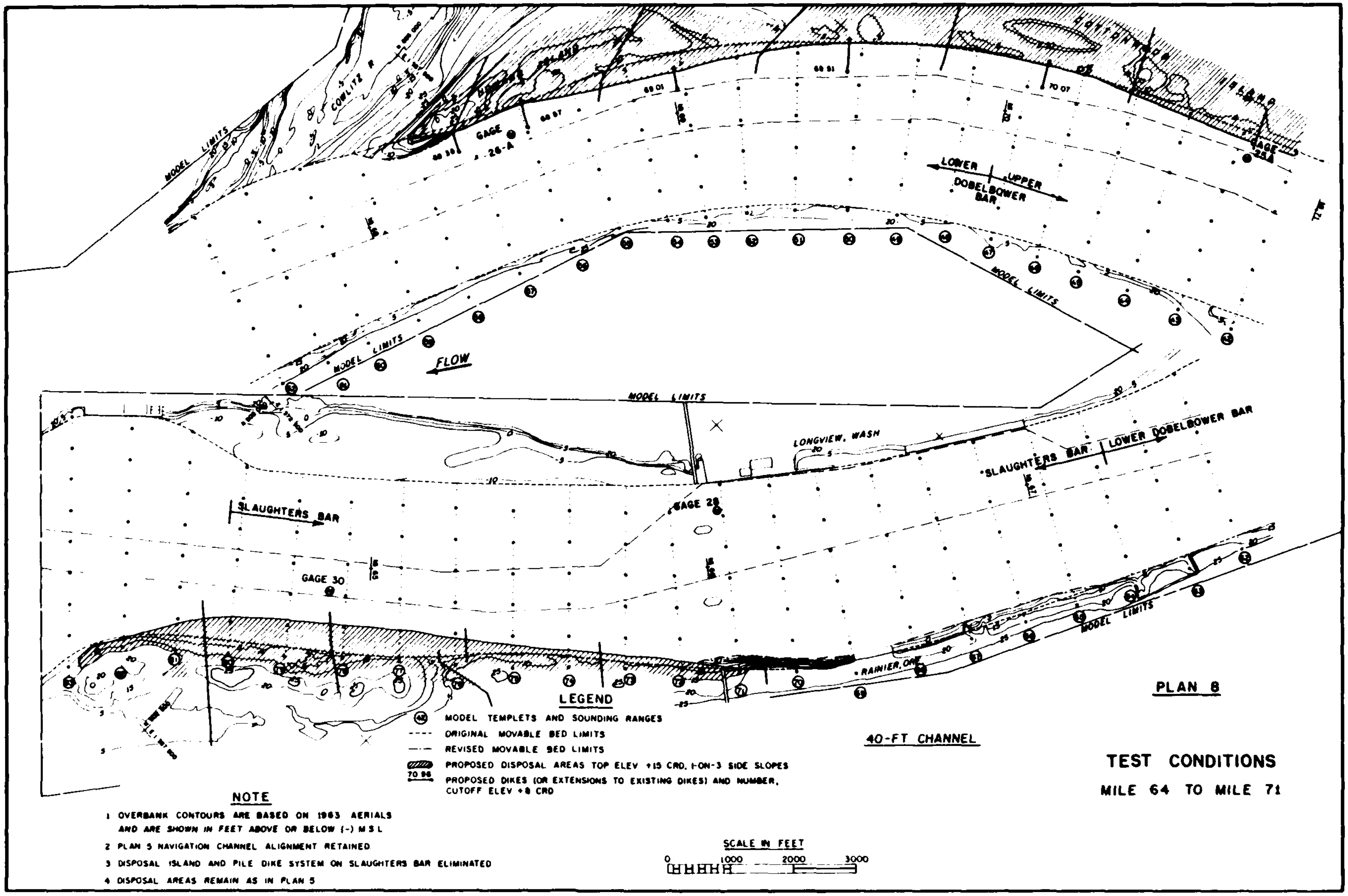
TEST CONDITIONS

MILE 71 TO MILE 78



40-FT CHANNEL

SHOALING DISTRIBUTION
KALAMA BAR
PLANS 1, 6, 7, AND 8


TEST CONDITIONS
MILE 64 TO MILE 71
PLAN 8
40-FT CHANNEL
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
70.96
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD
NOTE
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2 PLAN 5 NAVIGATION CHANNEL ALIGNMENT RETAINED
3 DISPOSAL ISLAND AND PILE DIKE SYSTEM ON SLAUGHTERS BAR ELIMINATED
4 DISPOSAL AREAS REMAIN AS IN PLAN 5
SCALE IN FEET
0
1000
2000
3000
FLOW
MODEL LIMITS
LOWER
UPPER
DOBELBOWER BAR
SLAUGHTERS BAR
LOWER DOBELBOWER BAR
SLAUGHTERS BAR
LONGVIEW, WASH
RAINIER, ORE
GAGE 26-A
GAGE 28
GAGE 30
COWLITZ R
COTTONWOOD ISLAND

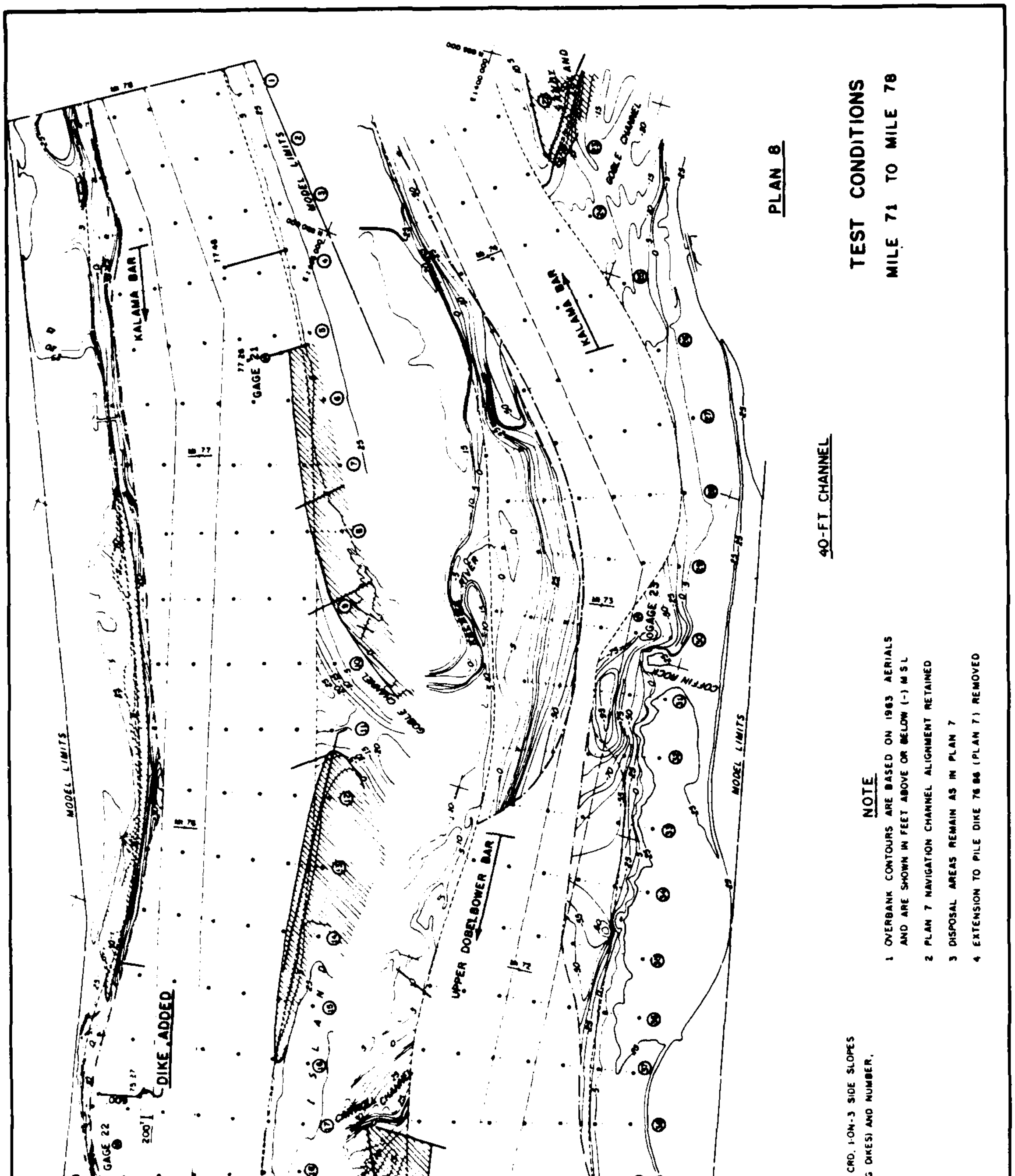
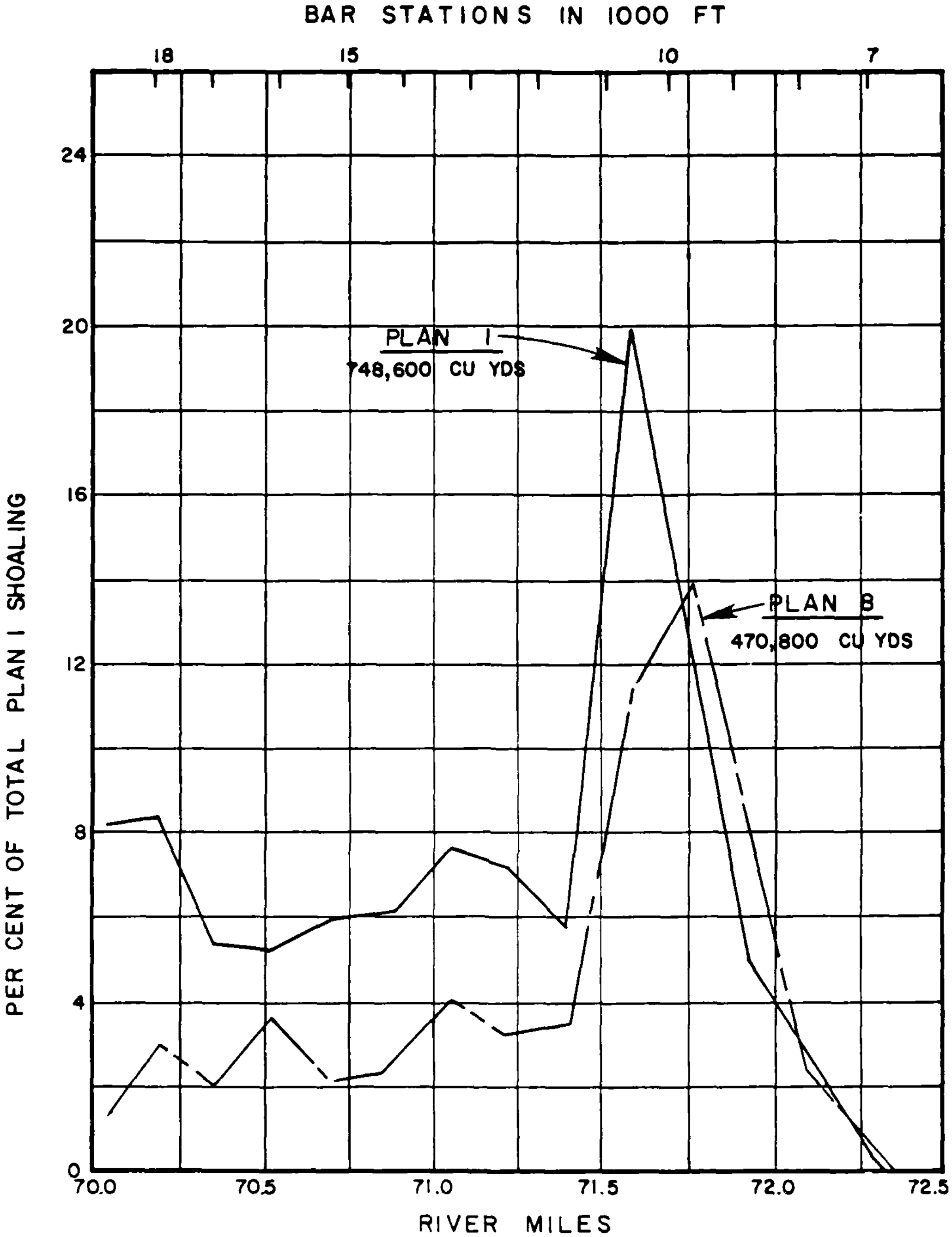
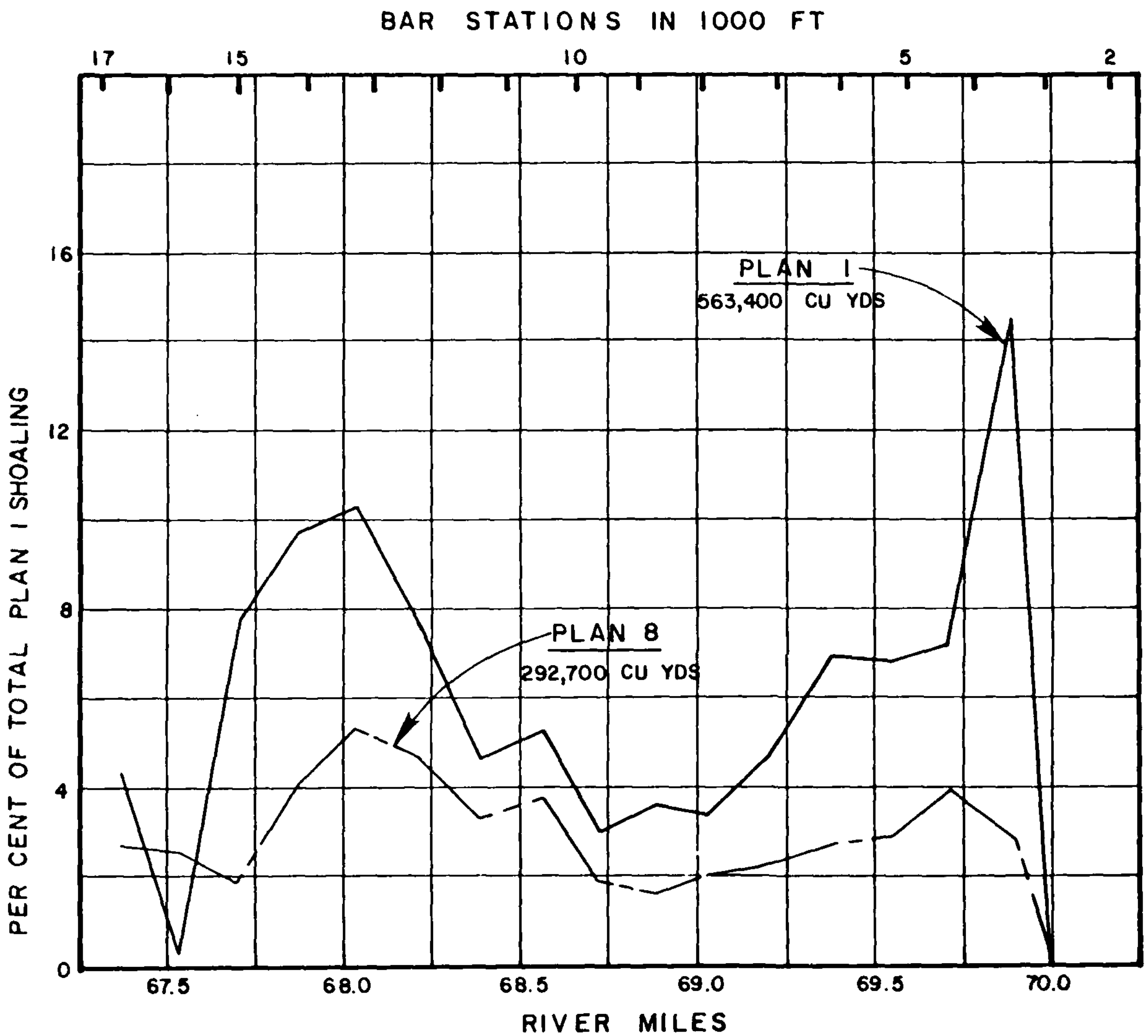

PLAN 8
TEST CONDITIONS
MILE 71 TO MILE 78
40-FT CHANNEL
NOTE
1 OVERBANK CONTOURS ARE BASED ON 1983 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2 PLAN 7 NAVIGATION CHANNEL ALIGNMENT RETAINED
3 DISPOSAL AREAS REMAIN AS IN PLAN 7
4 EXTENSION TO PILE DIKE 78.86 (PLAN 7) REMOVED
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD
SCALE IN FEET
0
1000
2000
3000
MODEL LIMITS
KALAMA BAR
GAGE 21
GAGE 22
GAGE 23
GAGE 25A
DIKE ADDED
UPPER DOBELBOWER BAR
COFFIN ROCK
FLOW
KALAMA
COTTONWOOD ISLAND
GOBLE CHANNEL

PLATE 51



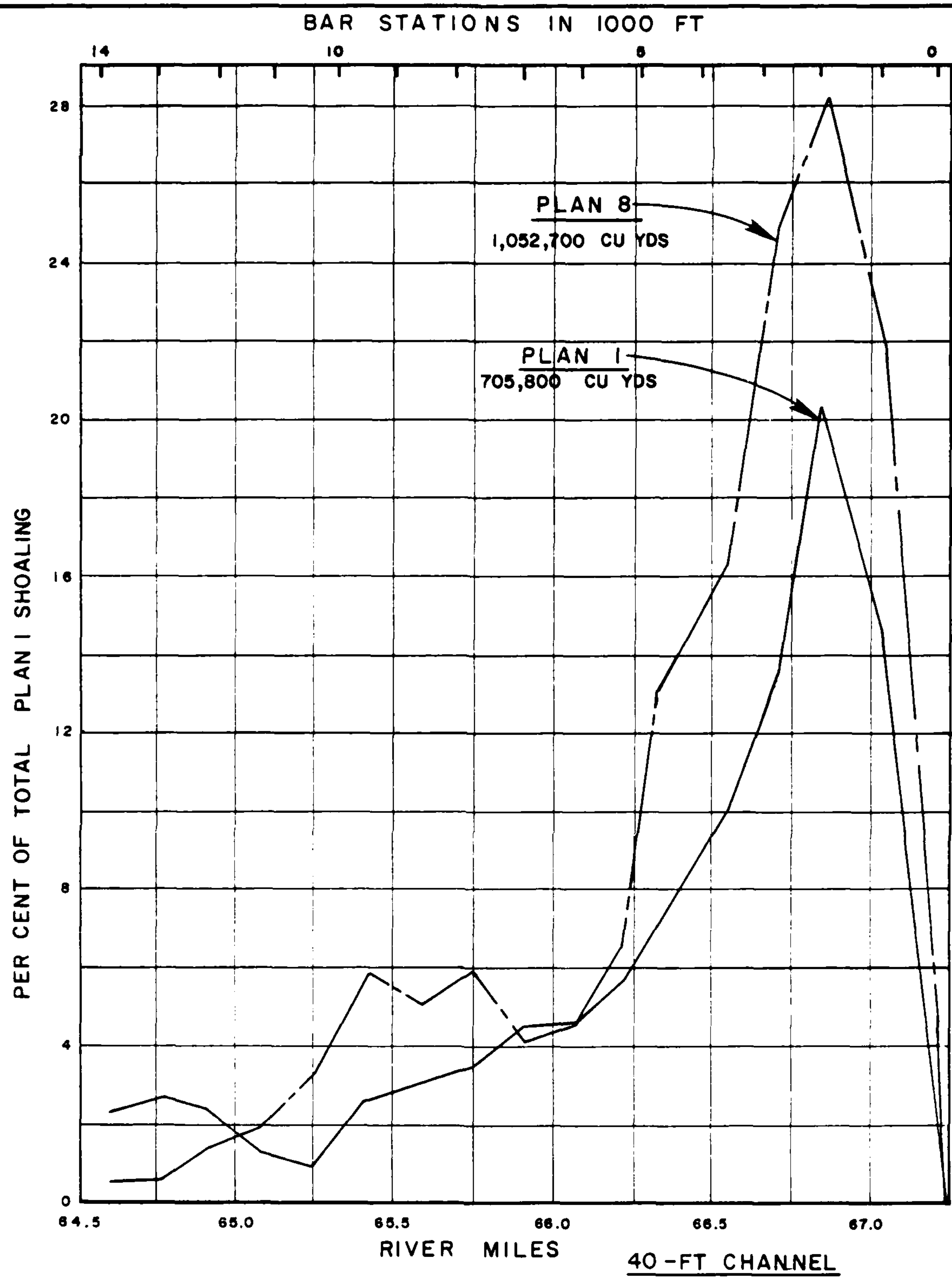
40-FT CHANNEL

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1 AND 8



40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS I AND 8



SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS 1 AND 8

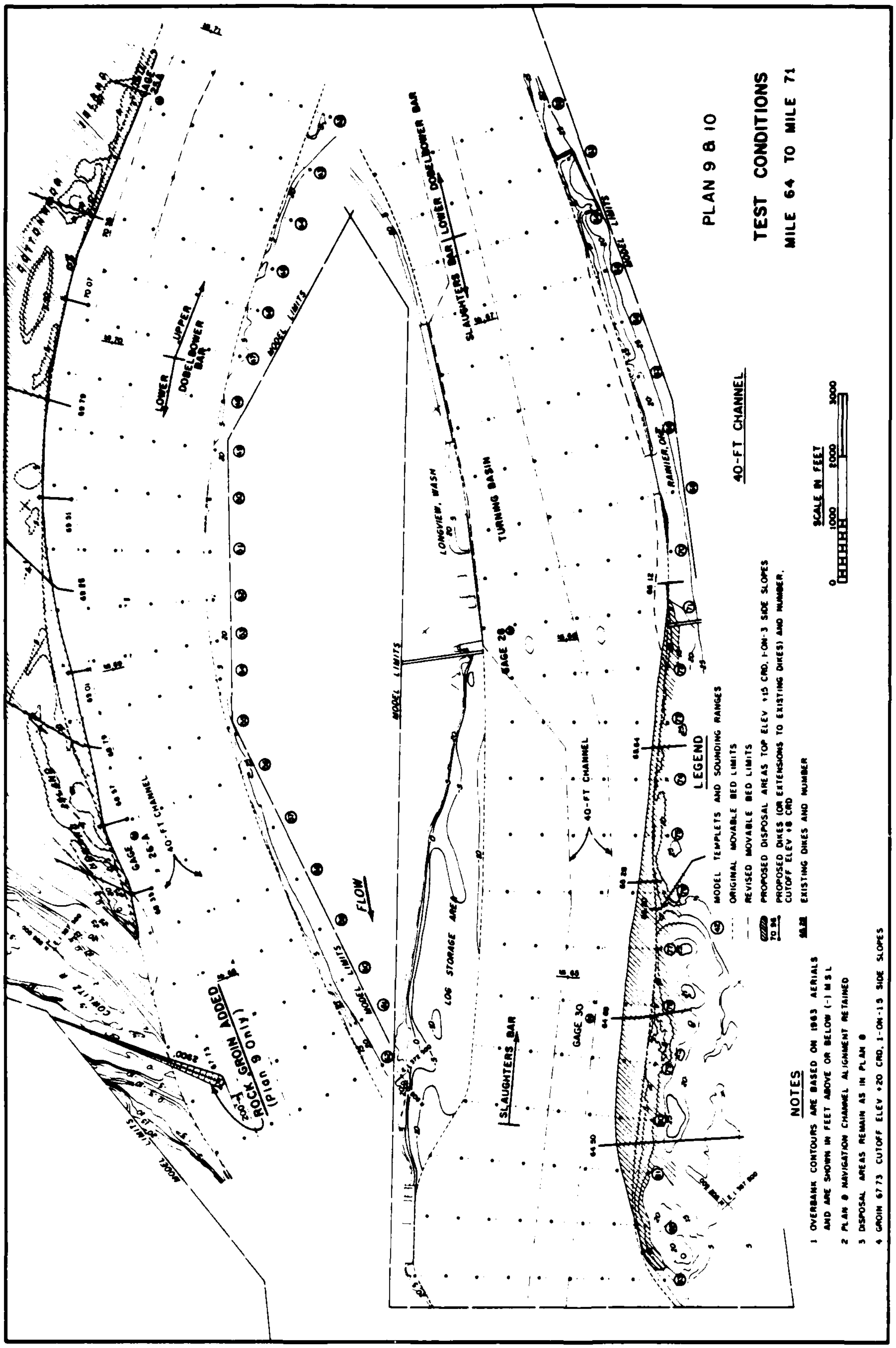
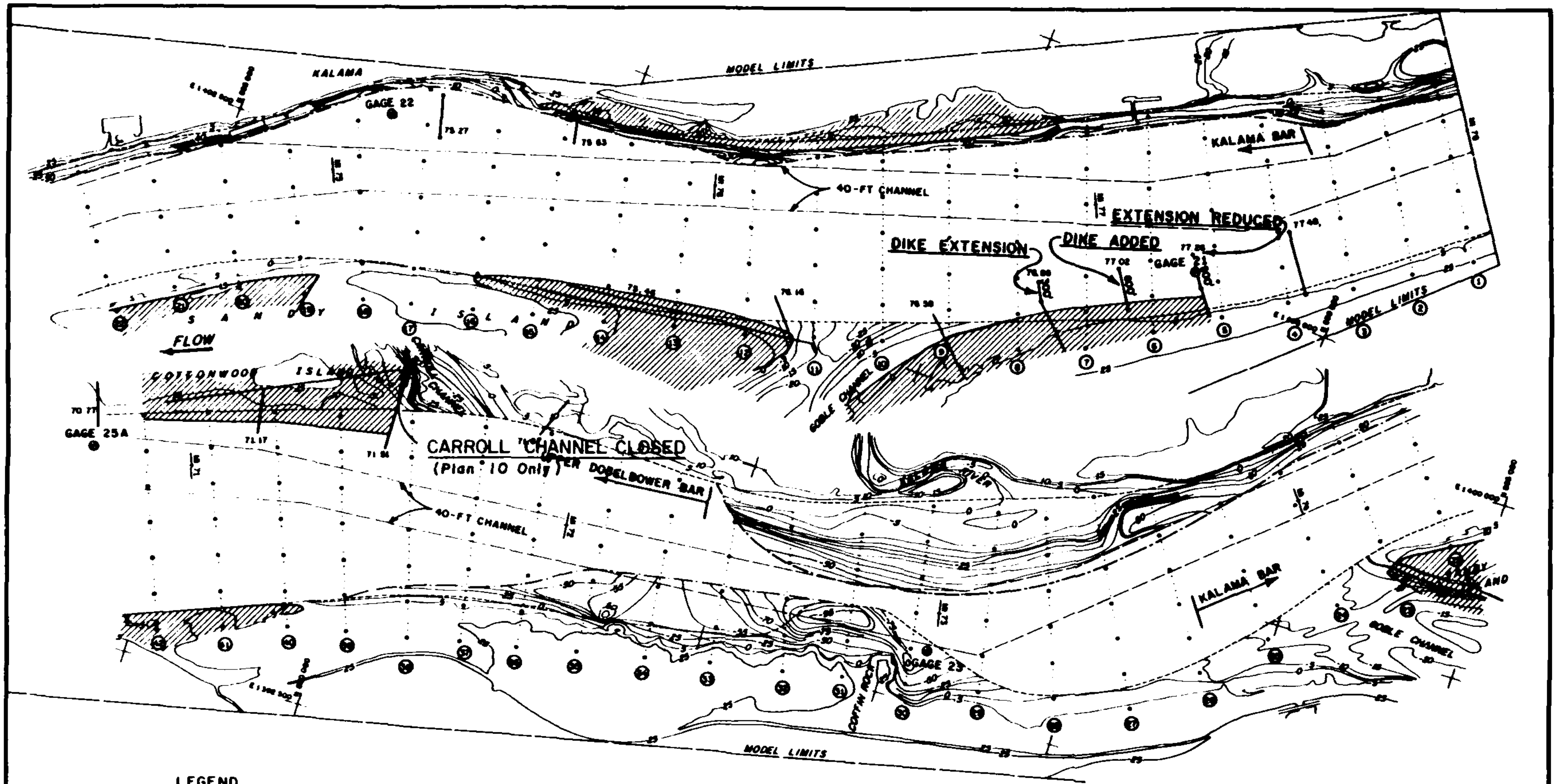

PLAN 9 & 10
TEST CONDITIONS
MILE 64 TO MILE 71
40-FT CHANNEL
SCALE IN FEET
0 1000 2000 3000
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER. CUTOFF ELEV +8 CRD
EXISTING DIKES AND NUMBER
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2 PLAN 8 NAVIGATION CHANNEL ALIGNMENT RETAINED
3 DISPOSAL AREAS REMAIN AS IN PLAN 8
4 GROIN 67.73 CUTOFF ELEV +20 CRD, 1-ON-1.5 SIDE SLOPES
ROCK GROIN ADDED
(Plan 9 Only)
SLAUGHTERS BAR
LOG STORAGE AREA
TURNING BASIN
LONGVIEW, WASH.
FLOW
MODEL LIMITS
40-FT CHANNEL
GAGE 28
GAGE 30
LOWER DOBELBOWER BAR
UPPER
SLAUGHTERS BAR
RAINIER, ORE.

PLATE 55



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
- 77.28 PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD
- 77.16 EXISTING DIKES AND NUMBER

NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. PLAN 8 NAVIGATION CHANNEL ALIGNMENT RETAINED
3. DISPOSAL AREAS REMAIN AS IN PLAN 8
4. DIKE EXTENSION 75.86 ROCKED TO ELEV -10 CRD EXCEPT FOR RIVERWARD 200 FT

40-FT CHANNEL

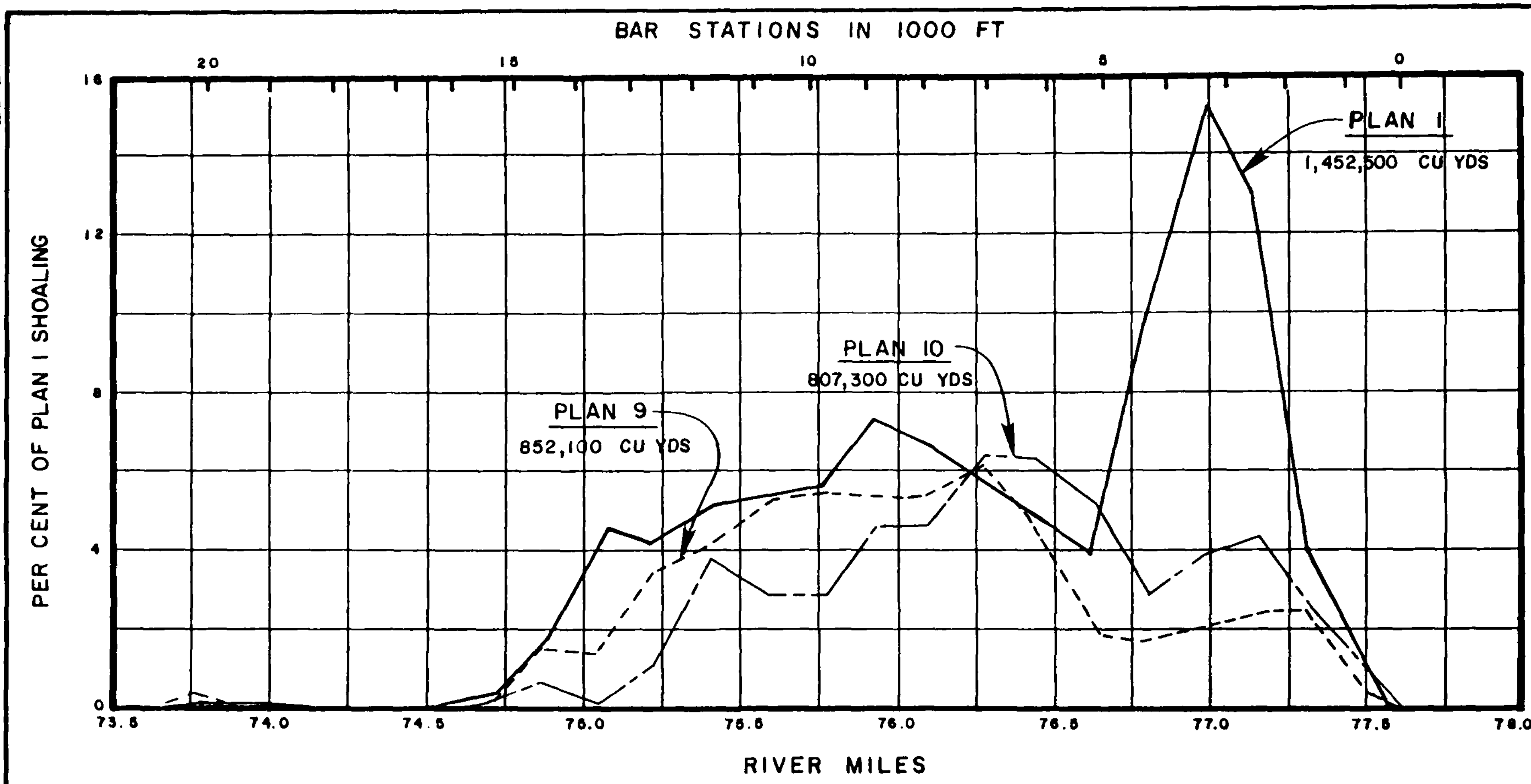
SCALE IN FEET

0 1000 2000 3000

PLAN 9 & 10

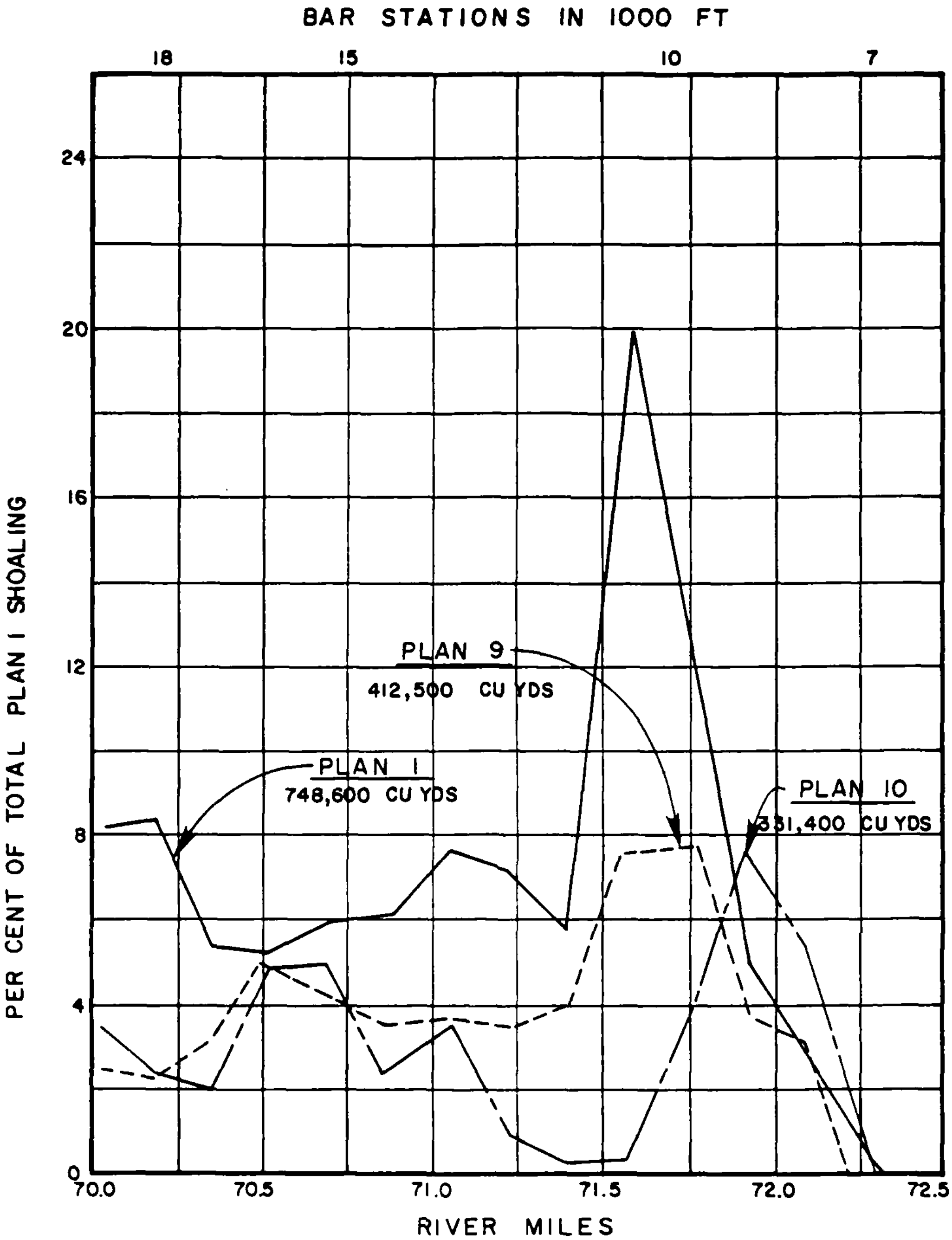
TEST CONDITIONS

MILE 71 TO MILE 78



SHOALING DISTRIBUTION
KALAMA BAR
PLANS 1, 9 AND 10

40-FT CHANNEL

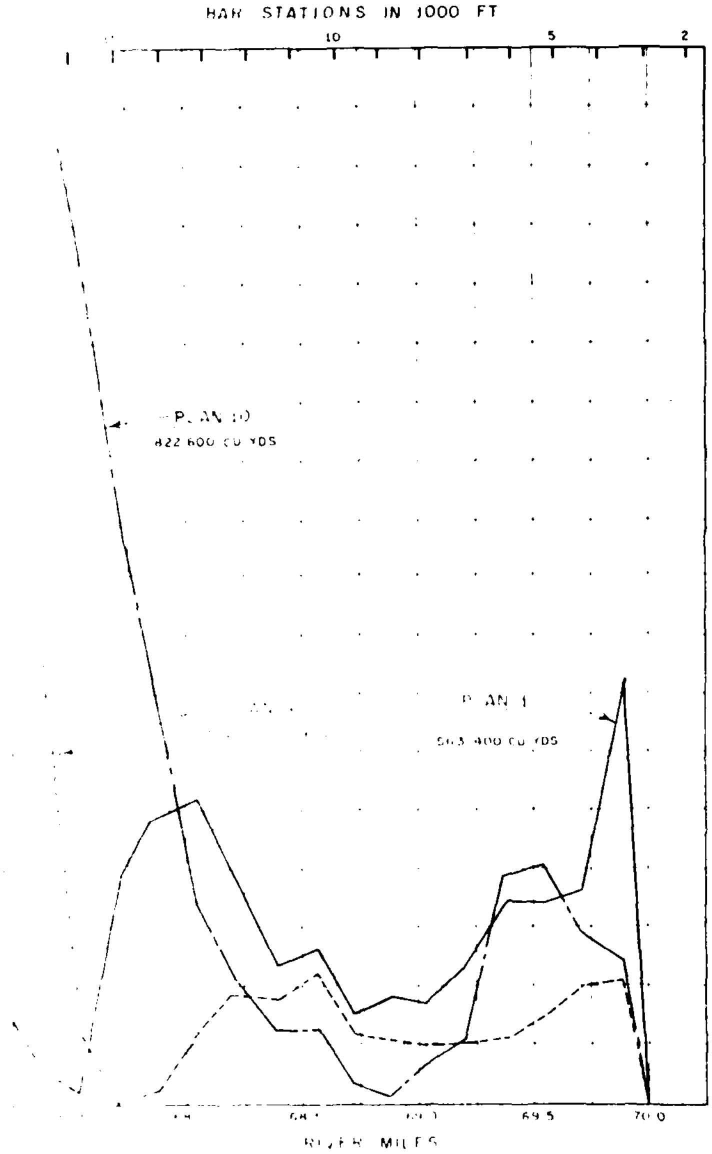


40-FT CHANNEL

NOTE

QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40 FT PLUS 5-FT OVERDEPTH).

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1, 9 AND 10

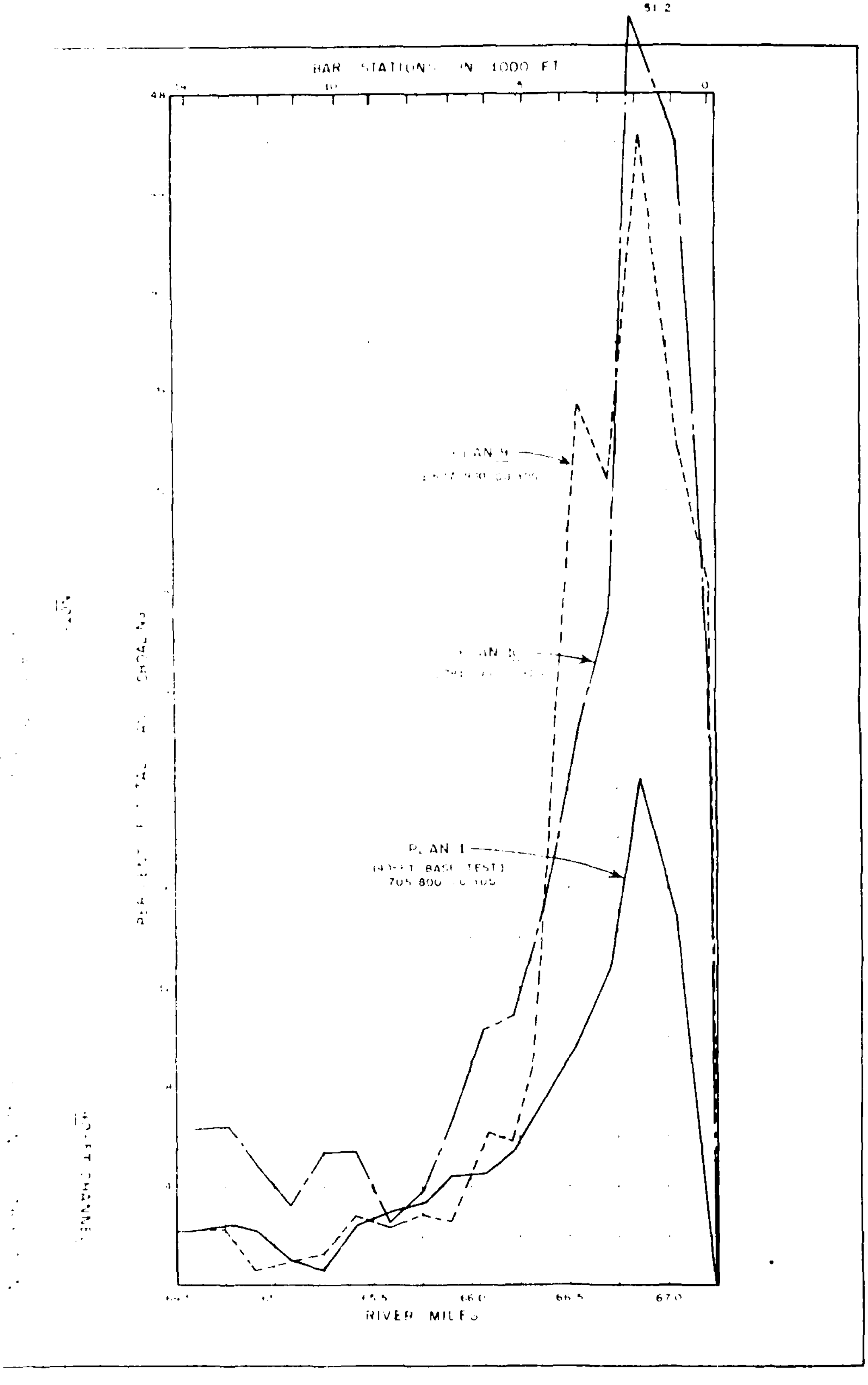


NOTE

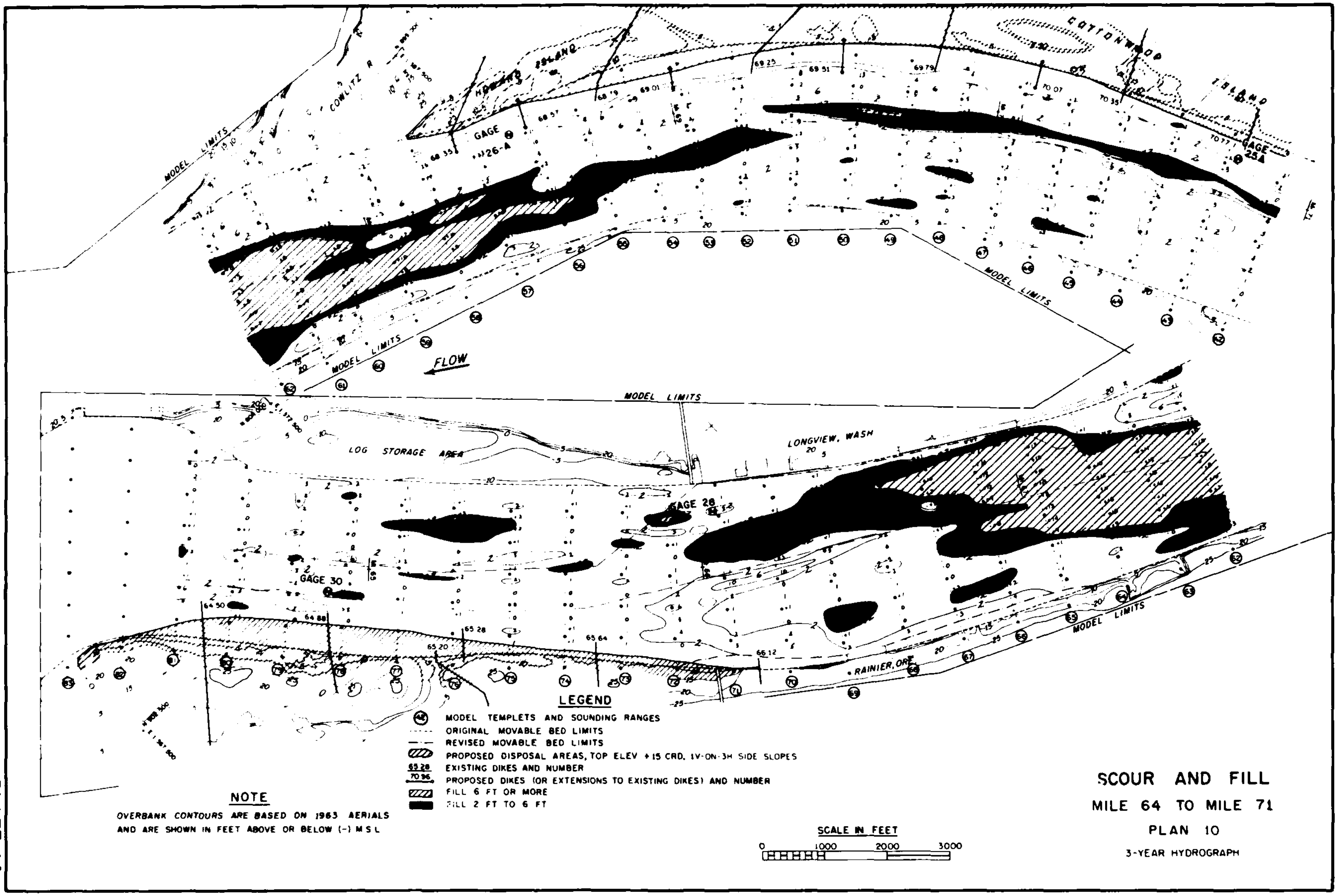
QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40 FT PLUS 5 FT OVERDEPTH)

40 FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS 1, 9 AND 10

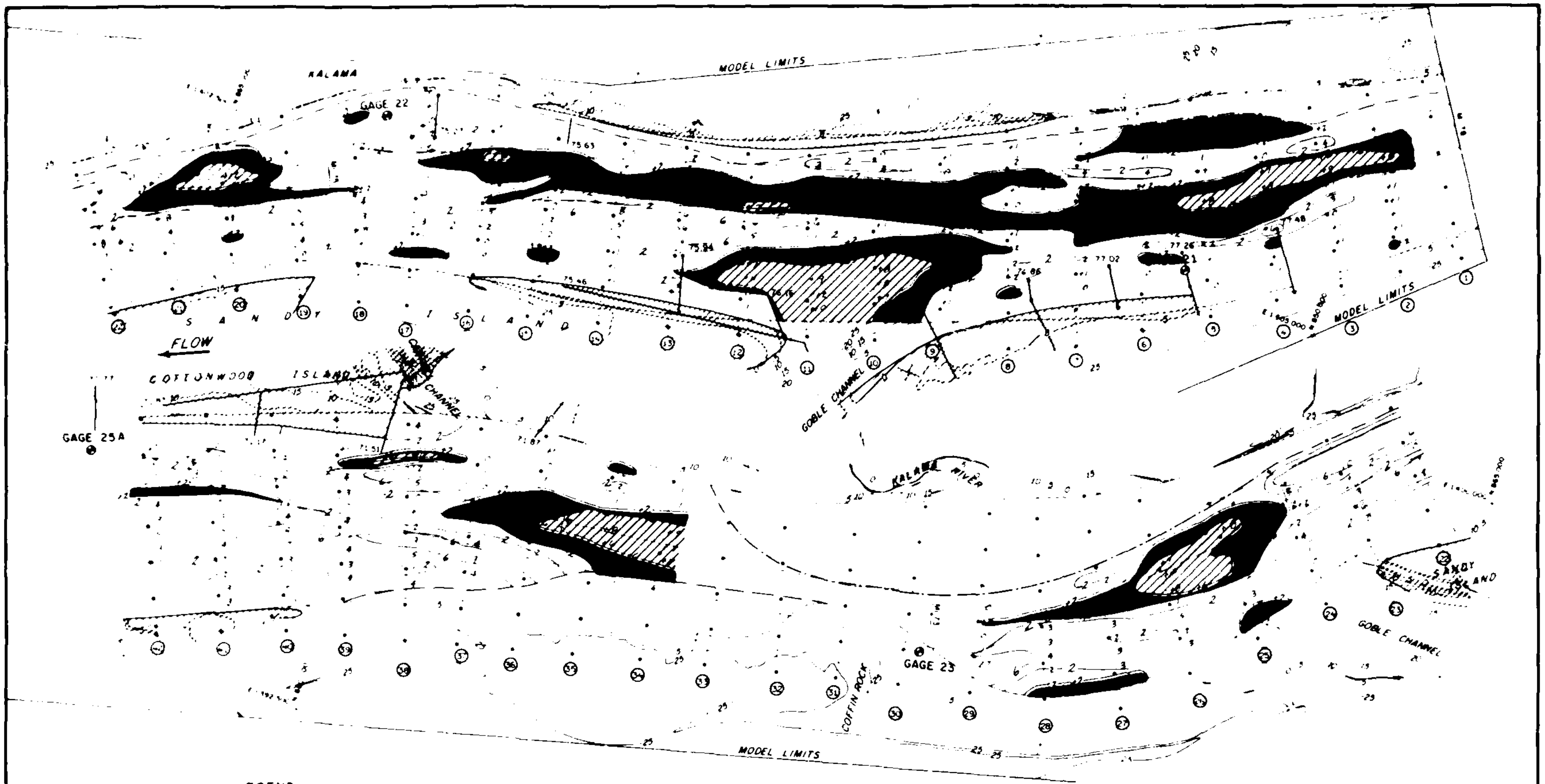


51.2
BAR STATIONS IN 1000 FT
48
10
5
0
PLAN 9
PLAN 1
(40-FT BASE TEST)
705 800
65.5
66.0
66.5
67.0
RIVER MILES



SCOUR AND FILL
MILE 64 TO MILE 71
PLAN 10
3-YEAR HYDROGRAPH
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1V-ON-3H SIDE SLOPES
65.28 EXISTING DIKES AND NUMBER
70.96 PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
SCALE IN FEET
0 1000 2000 3000
COTTONWOOD ISLAND
HOWARD ISLAND
COWLITZ R
GAGE 25A
GAGE 26-A
GAGE 28
GAGE 30
MODEL LIMITS
FLOW
LOG STORAGE AREA
LONGVIEW, WASH
RAINIER, ORE

PLATE 61



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1V ON 3H SIDE SLOPES
- 65.28 EXISTING DIKES AND NUMBER
- 75.46 PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
- FILL 6 FT OR MORE
- FILL 2 FT TO 6 FT

NOTE

OVERHANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M.S.L.

SCALE IN FEET

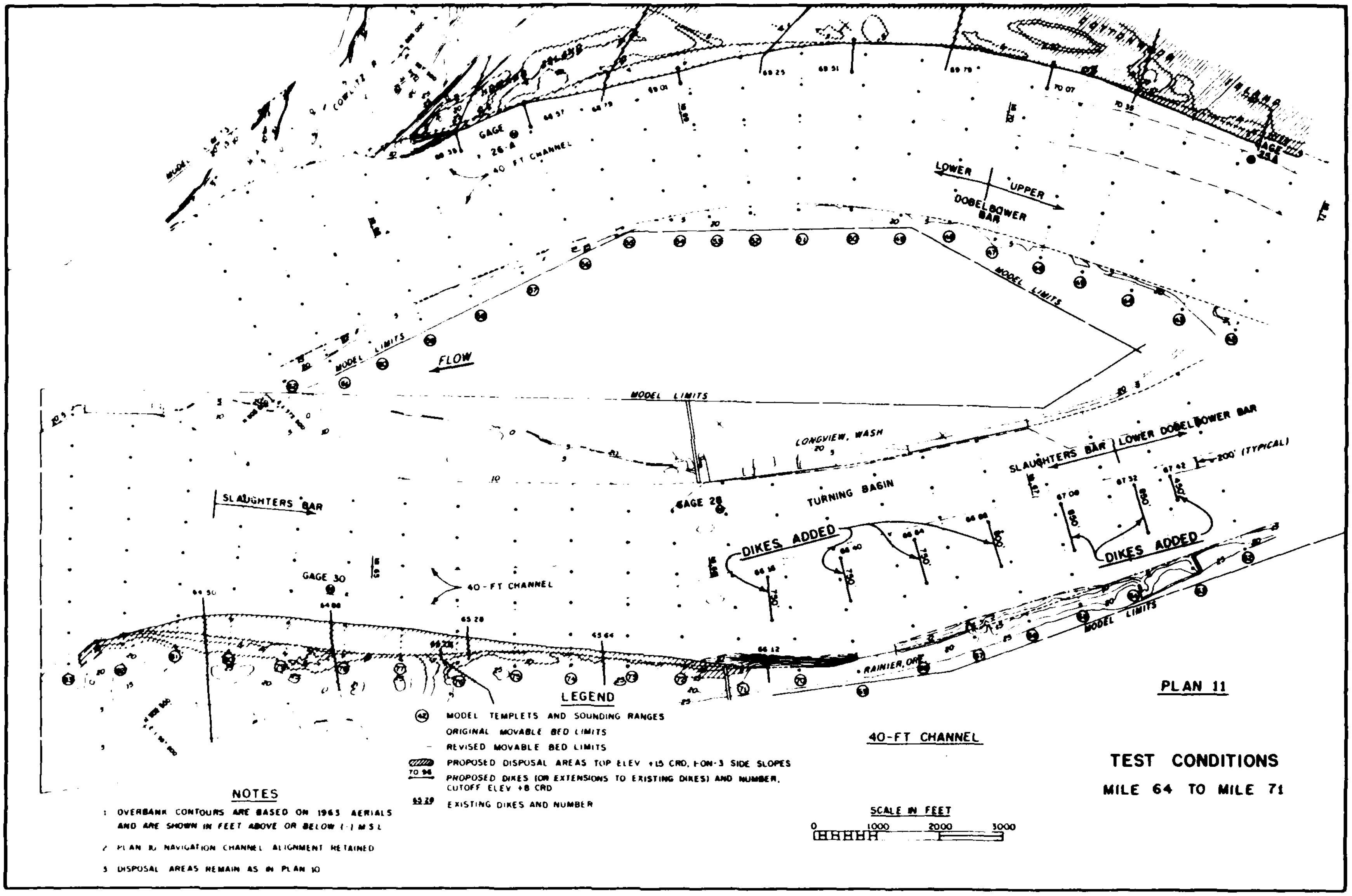
0 1000 2000 3000

SCOUR AND FILL

MILE 71 TO MILE 78

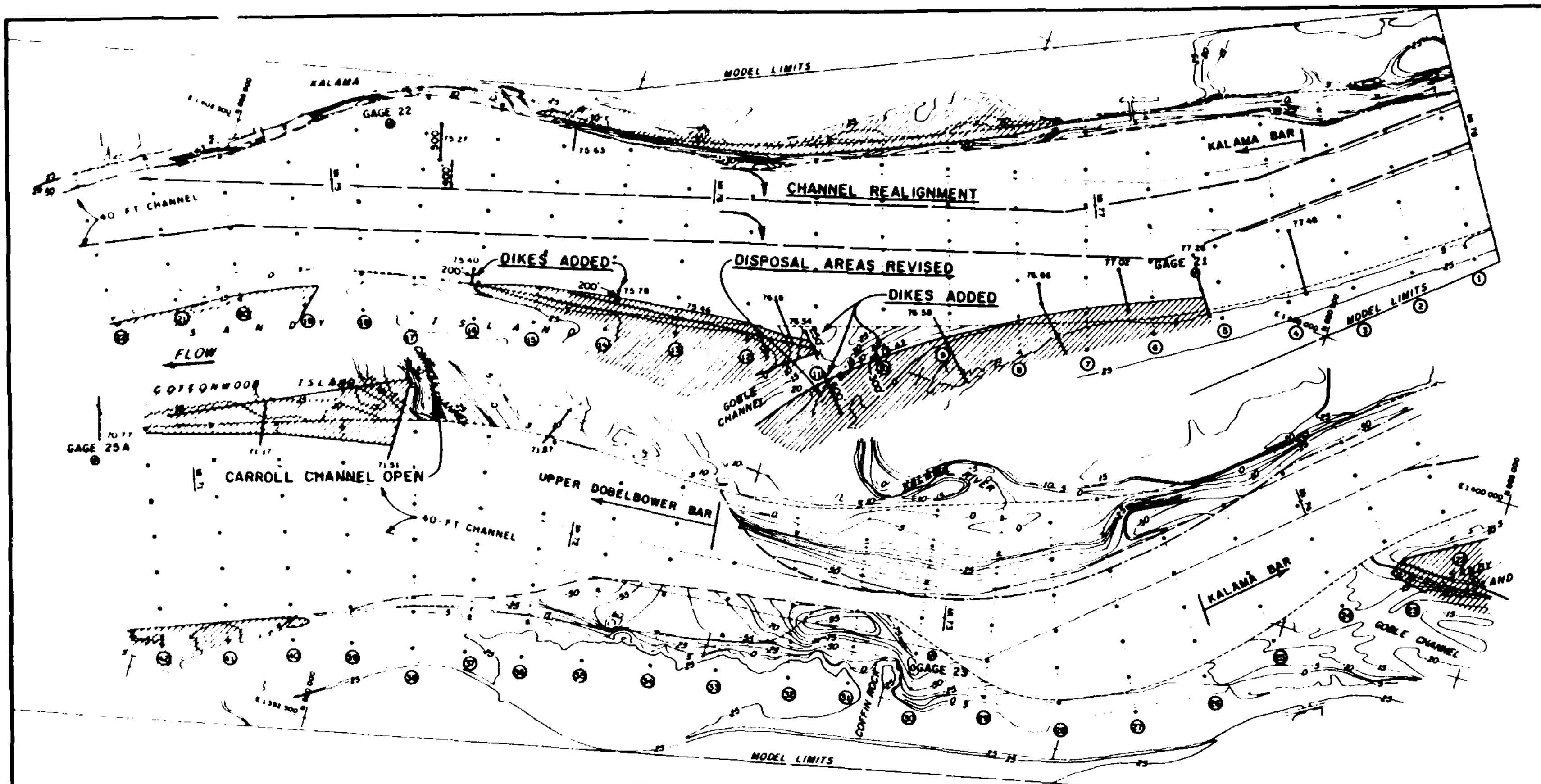
PLAN 10

3-YEAR HYDROGRAPH



PLAN 11
TEST CONDITIONS
MILE 64 TO MILE 71
40-FT CHANNEL
SCALE IN FEET
0 1000 2000 3000
LOWER UPPER
DOBELBOWER BAR
MODEL LIMITS
FLOW
LONGVIEW, WASH
TURNING BASIN
SLAUGHTERS BAR
LOWER DOBELBOWER BAR
200' (TYPICAL)
DIKES ADDED
GAGE 28
GAGE 30
GAGE 26-A
40-FT CHANNEL
RAINIER, ORE
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD
EXISTING DIKES AND NUMBER
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2 PLAN 10 NAVIGATION CHANNEL ALIGNMENT RETAINED
3 DISPOSAL AREAS REMAIN AS IN PLAN 10

PLATE 63



LEGEND

- (42) MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1 ON-3 SIDE SLOPES
- 77.26 PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER, CUTOFF ELEV +8 CRD
- 70.77 EXISTING DIKES AND NUMBER

SCALE IN FEET

0 1000 2000 3000

40-FT CHANNEL

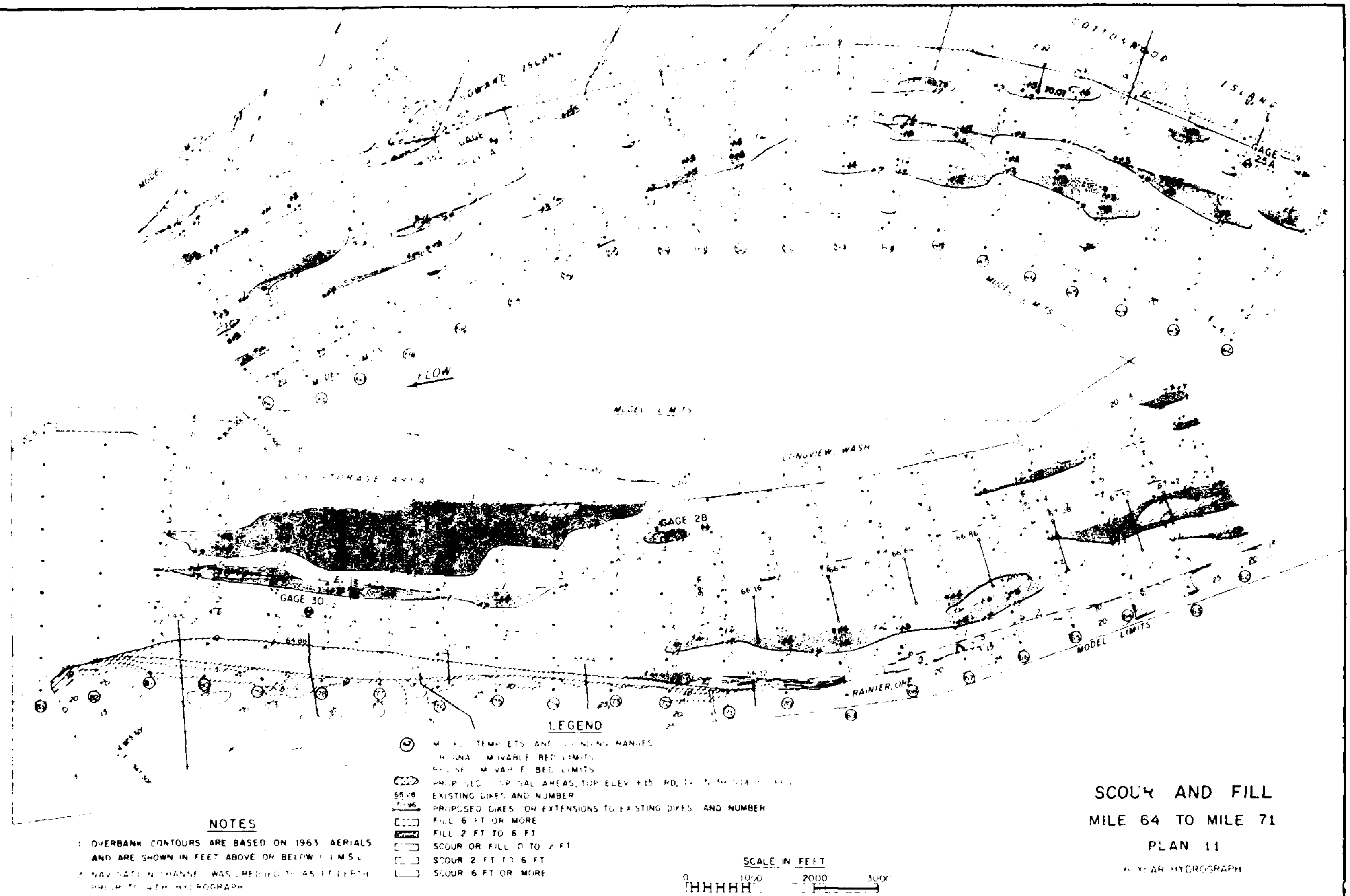
NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. DIKE ACROSS CARROLL CHANNEL REMOVED
3. ENTRANCE TO GOBLE CHANNEL 200 FT BETWEEN DOLPHINS, 100 FT FROM EACH DOLPHIN TO TOE OF DISPOSAL

PLAN 11

TEST CONDITIONS

MILE 71 TO MILE 78



SCOUR AND FILL
MILE 64 TO MILE 71
PLAN 11

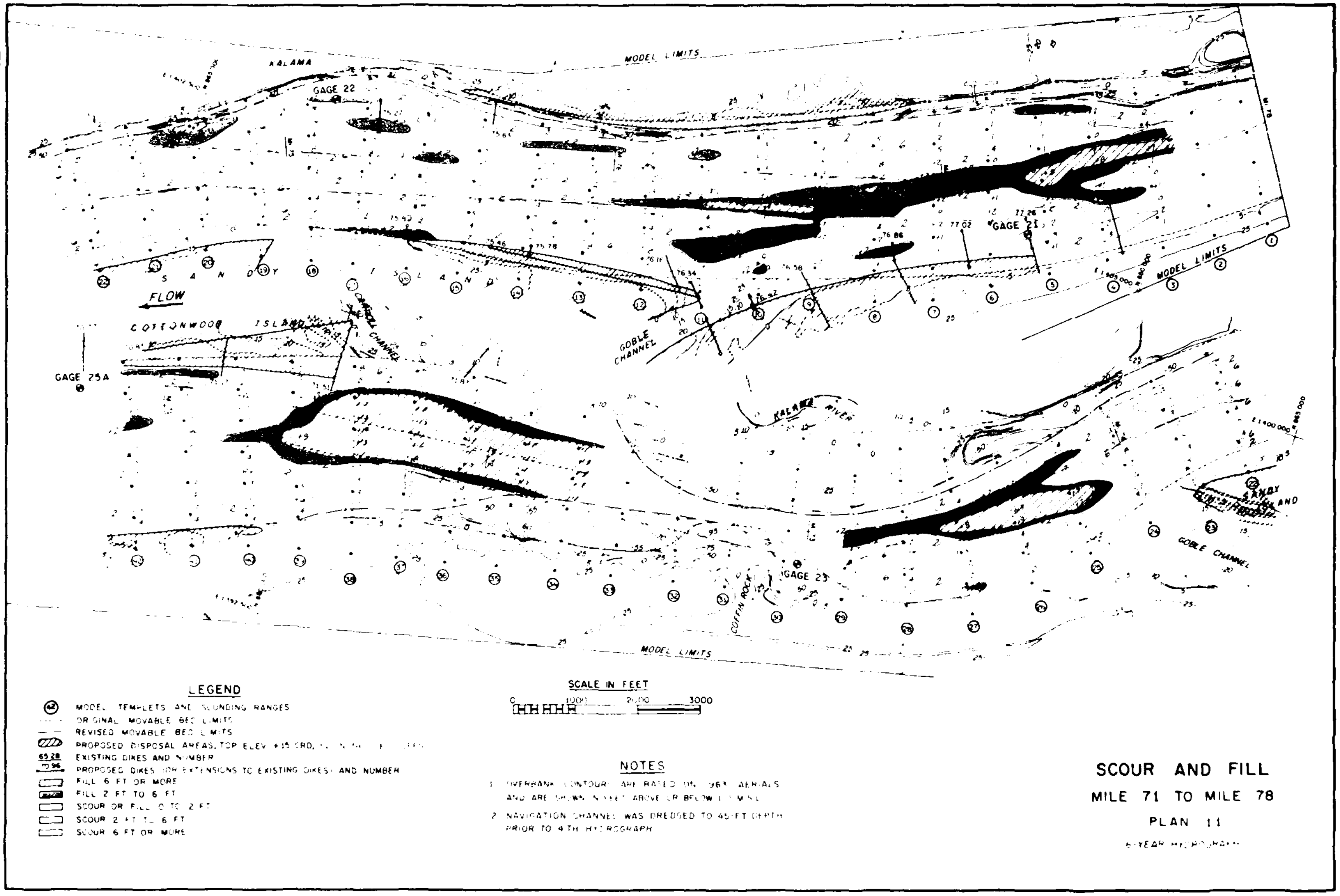
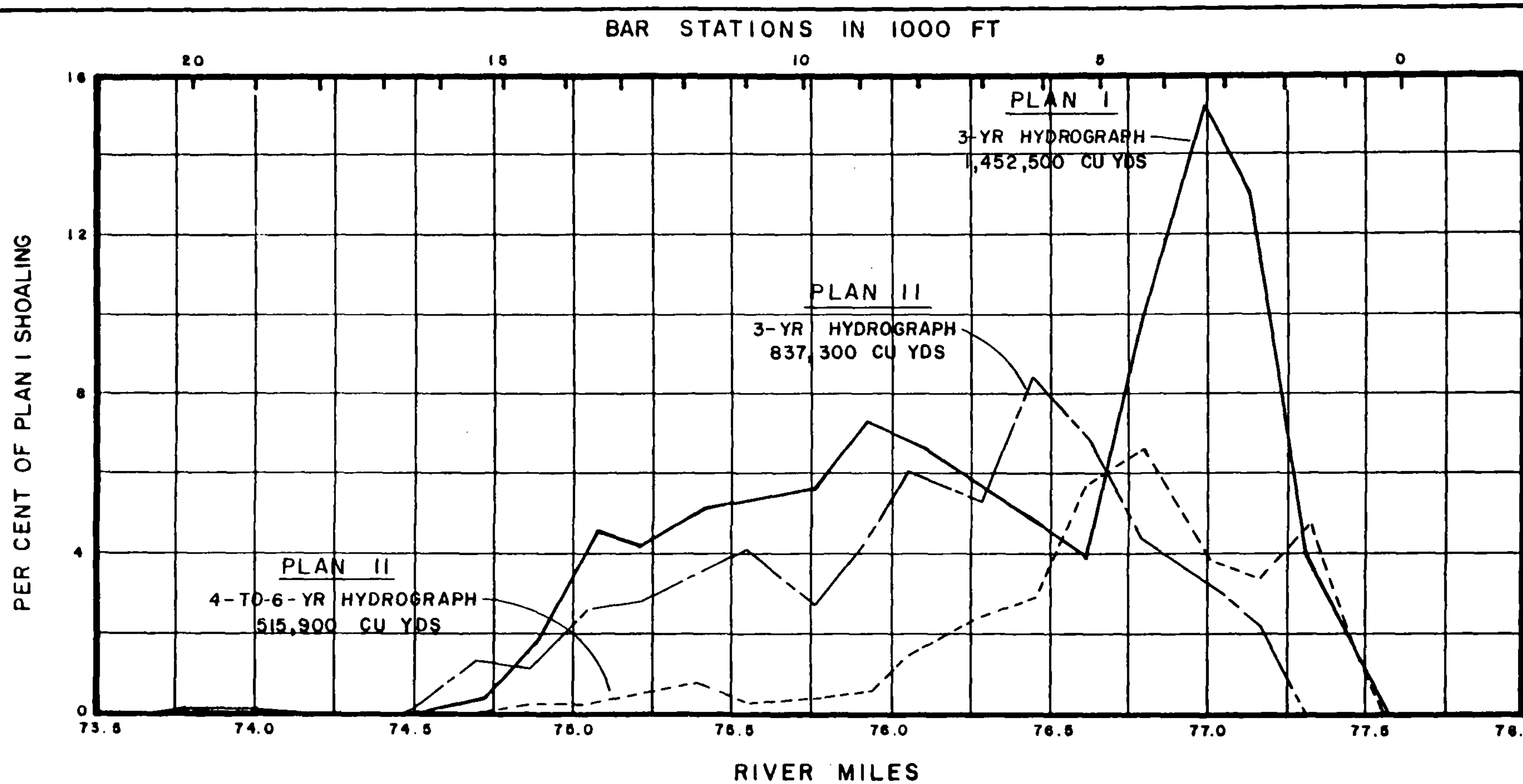

MODEL LIMITS
KALAMA
GAGE 22
GAGE 21
GAGE 23
GAGE 25A
FLOW
SANDY ISLAND
COTTONWOOD ISLAND
GOBLE CHANNEL
KALAMA RIVER
COFFIN ROCK
SANDY ISLAND
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
SCOUR OR FILL 0 TO 2 FT
SCOUR 2 FT TO 6 FT
SCOUR 6 FT OR MORE
SCALE IN FEET
0
1000
2000
3000
NOTES
2. NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH
SCOUR AND FILL
MILE 71 TO MILE 78
PLAN 11

PLATE 66

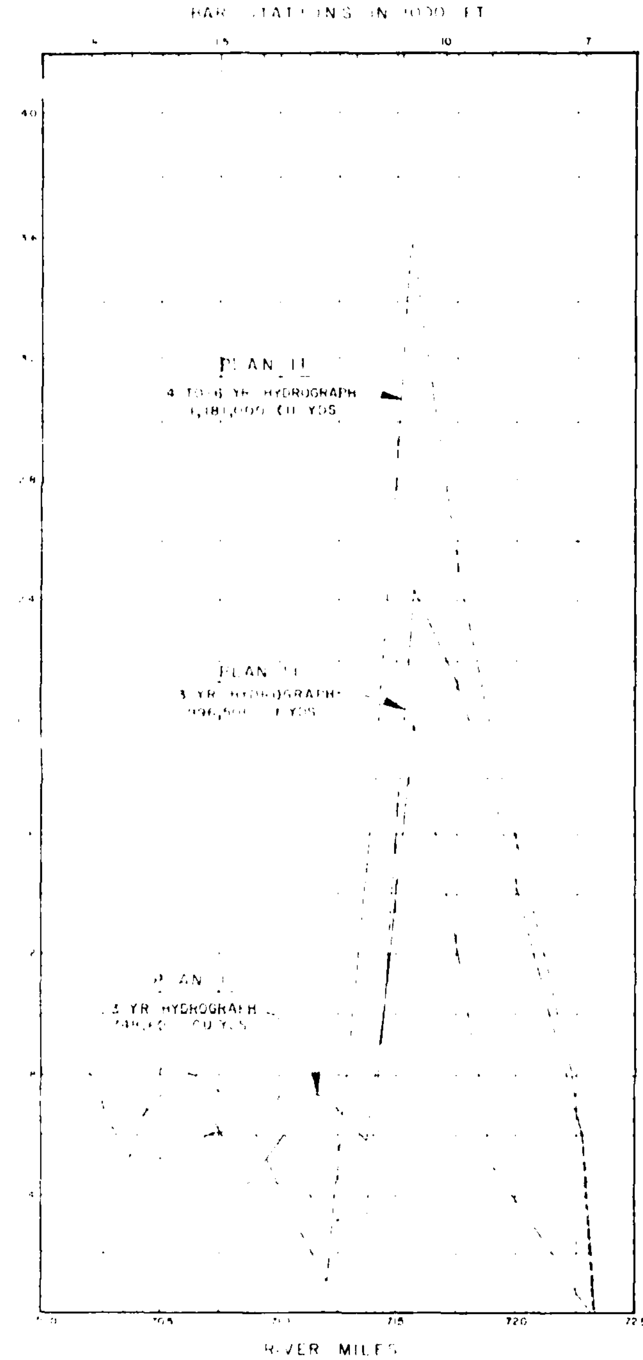


NOTES

1. NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH.
2. QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45CRD (40 FT PLUS 5-FT OVERDEPTH.

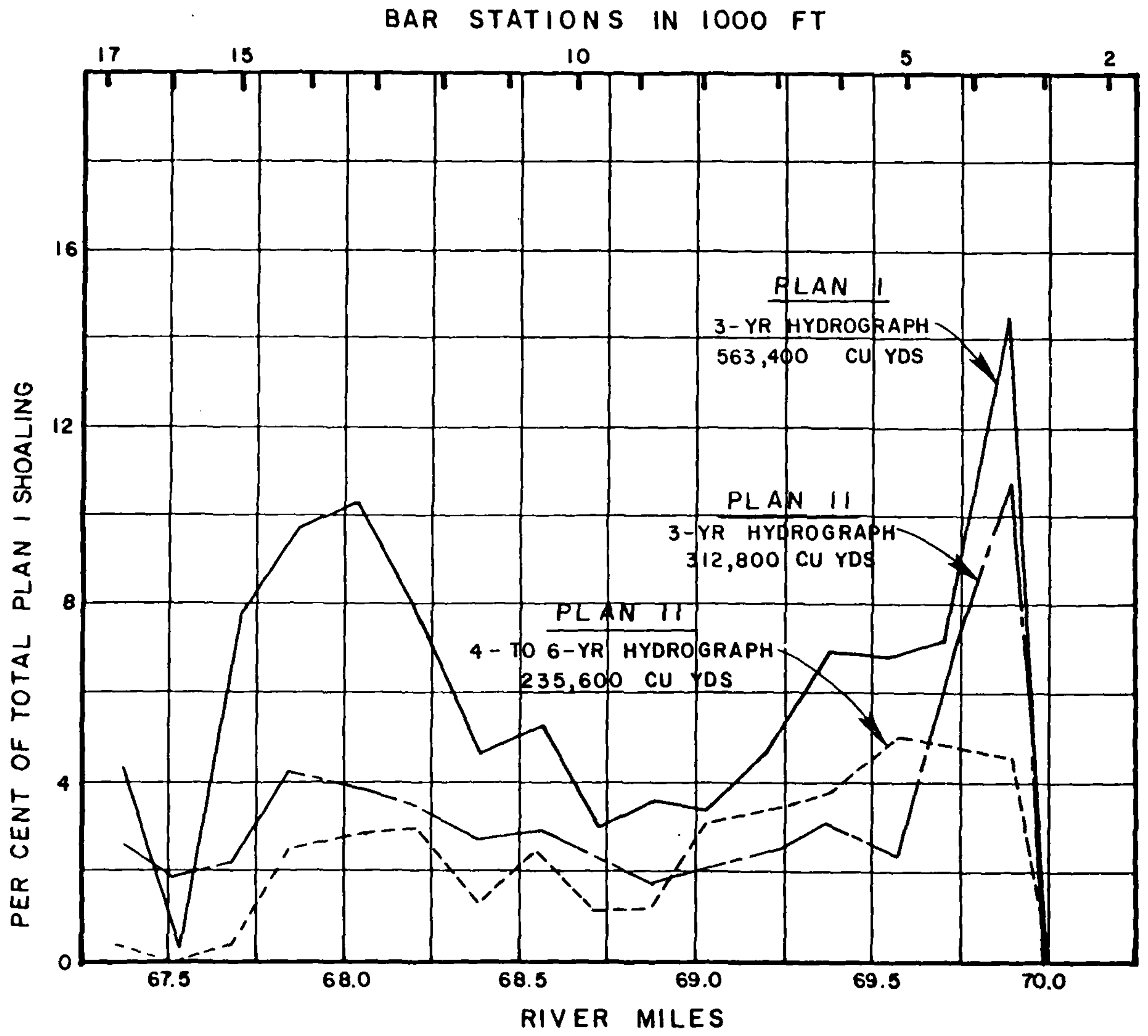
40-FT CHANNEL

SHOALING DISTRIBUTION
KALAMA BAR
PLANS I AND II



40-FT CHANNEL

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS I AND II

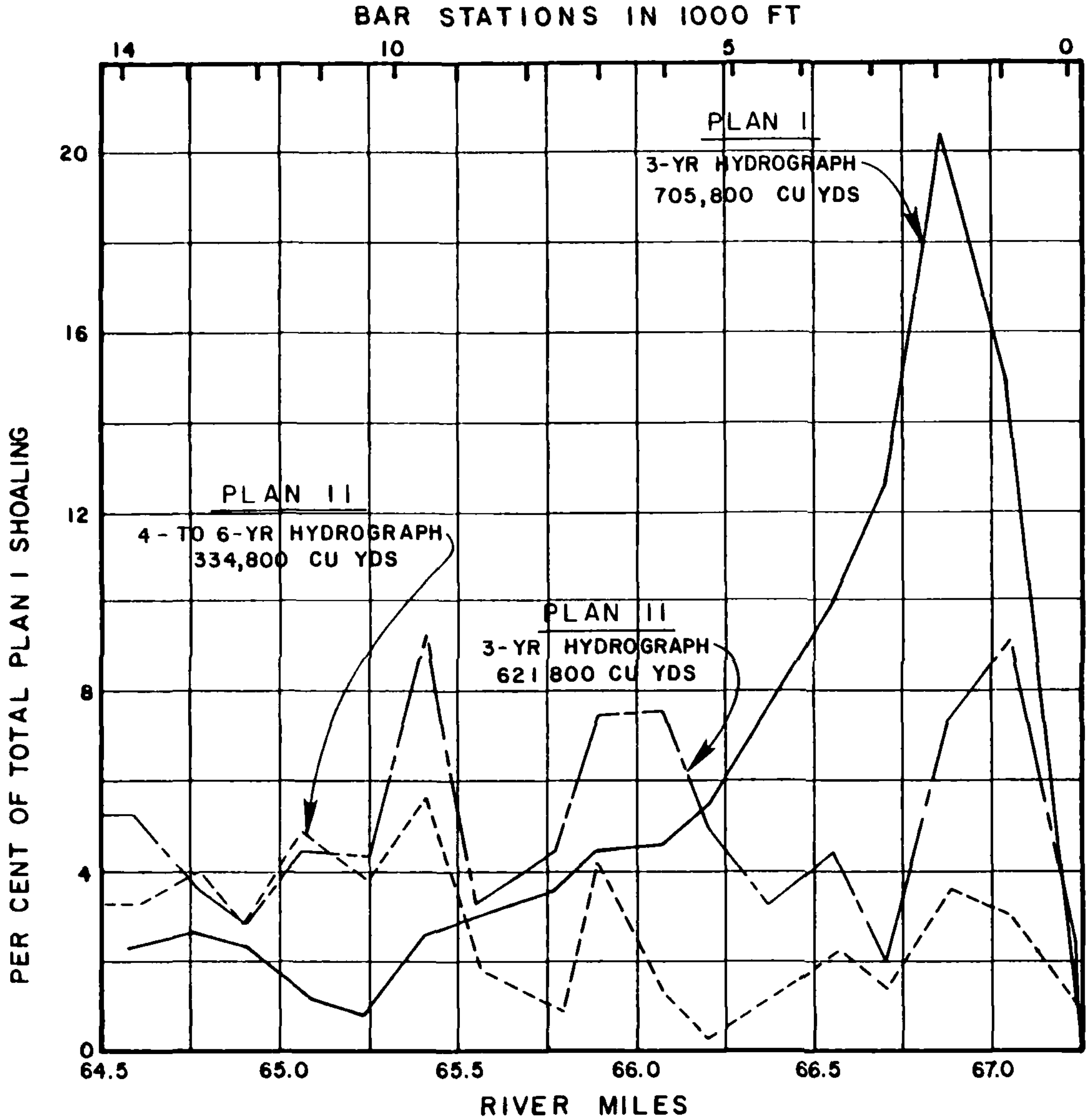


NOTES

1. NAVIGATION CHANNEL WAS DREDGED TO 45-FT *DEPTH* PRIOR TO 4TH HYDROGRAPH.
2. QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40FT PLUS 5-FT OVERDEPTH)

40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS I AND II

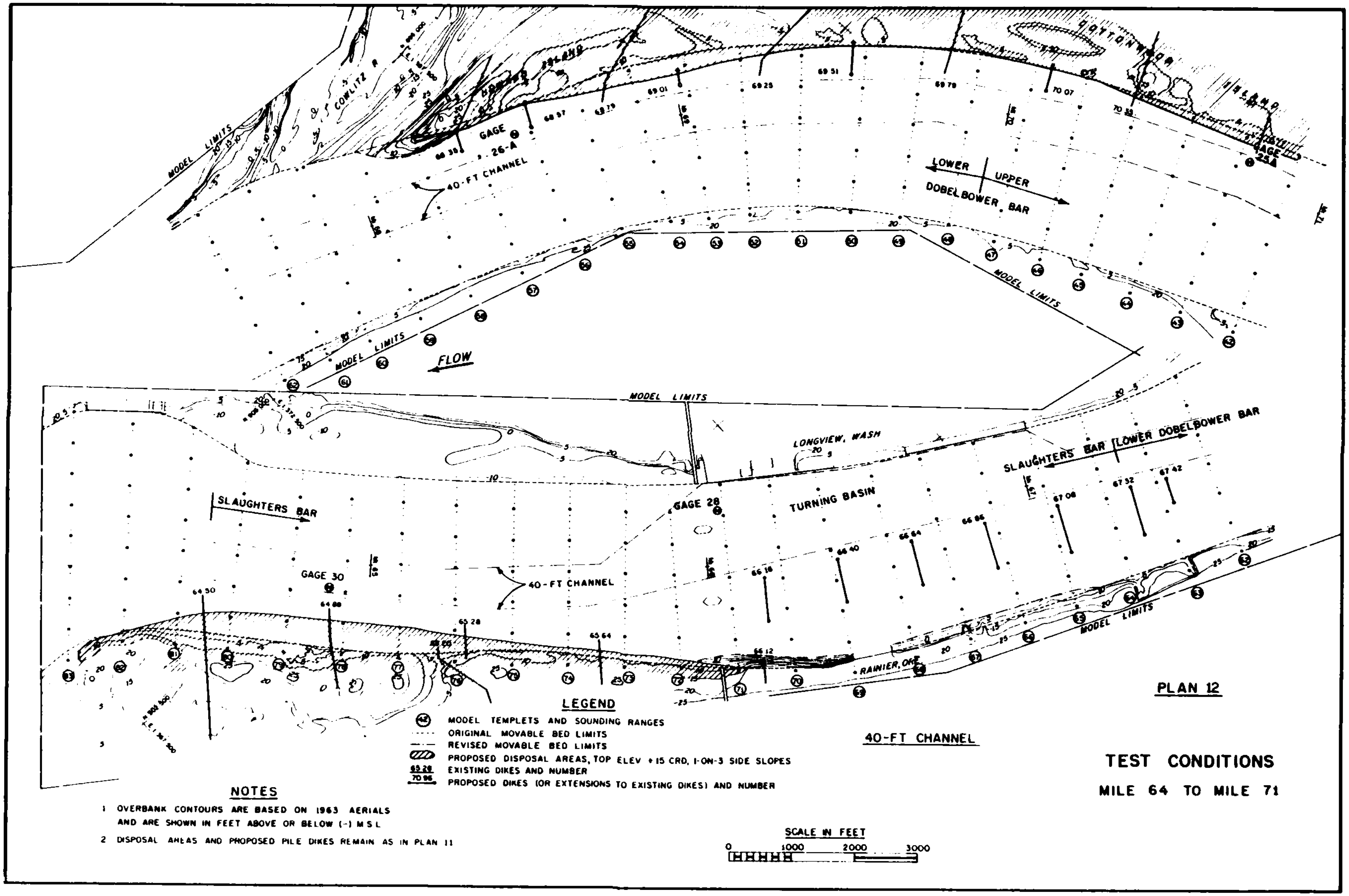


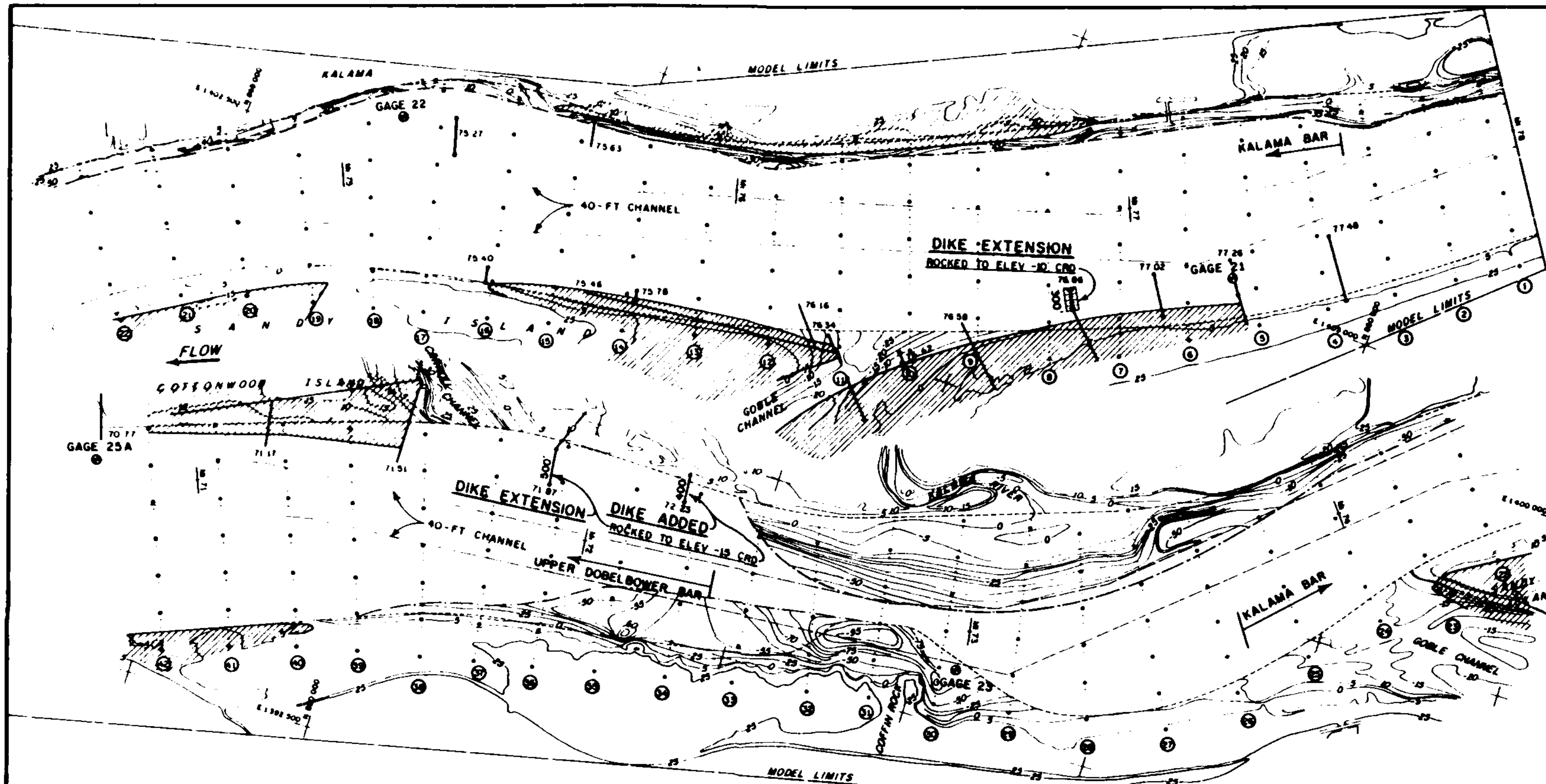
NOTES

1. NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4 TH HYDROGRAPH.
2. QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40 FT PLUS 5-FT OVERDEPTH)

40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR


PLAN 12
TEST CONDITIONS
MILE 64 TO MILE 71
40-FT CHANNEL
LOWER UPPER
DOBELBOWER BAR
SLAUGHTERS BAR LOWER DOBELBOWER BAR
SLAUGHTERS BAR
TURNING BASIN
LONGVIEW, WASH
RAINIER, ORE
GAGE 26-A
GAGE 25A
GAGE 28
GAGE 30
COTTONWOOD ISLAND
COWLITZ R
MODEL LIMITS
FLOW
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2 DISPOSAL AREAS AND PROPOSED PILE DIKES REMAIN AS IN PLAN 11
SCALE IN FEET
0 1000 2000 3000



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS, TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
- 69.28 EXISTING DIKES AND NUMBER
- 70.86 PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
- PROPOSED DIKE 76.86, ROCKED TO ELEV -10 CRD, 1-ON-1.5 SIDE SLOPES

SCALE IN FEET

0 1000 2000 3000

NOTES

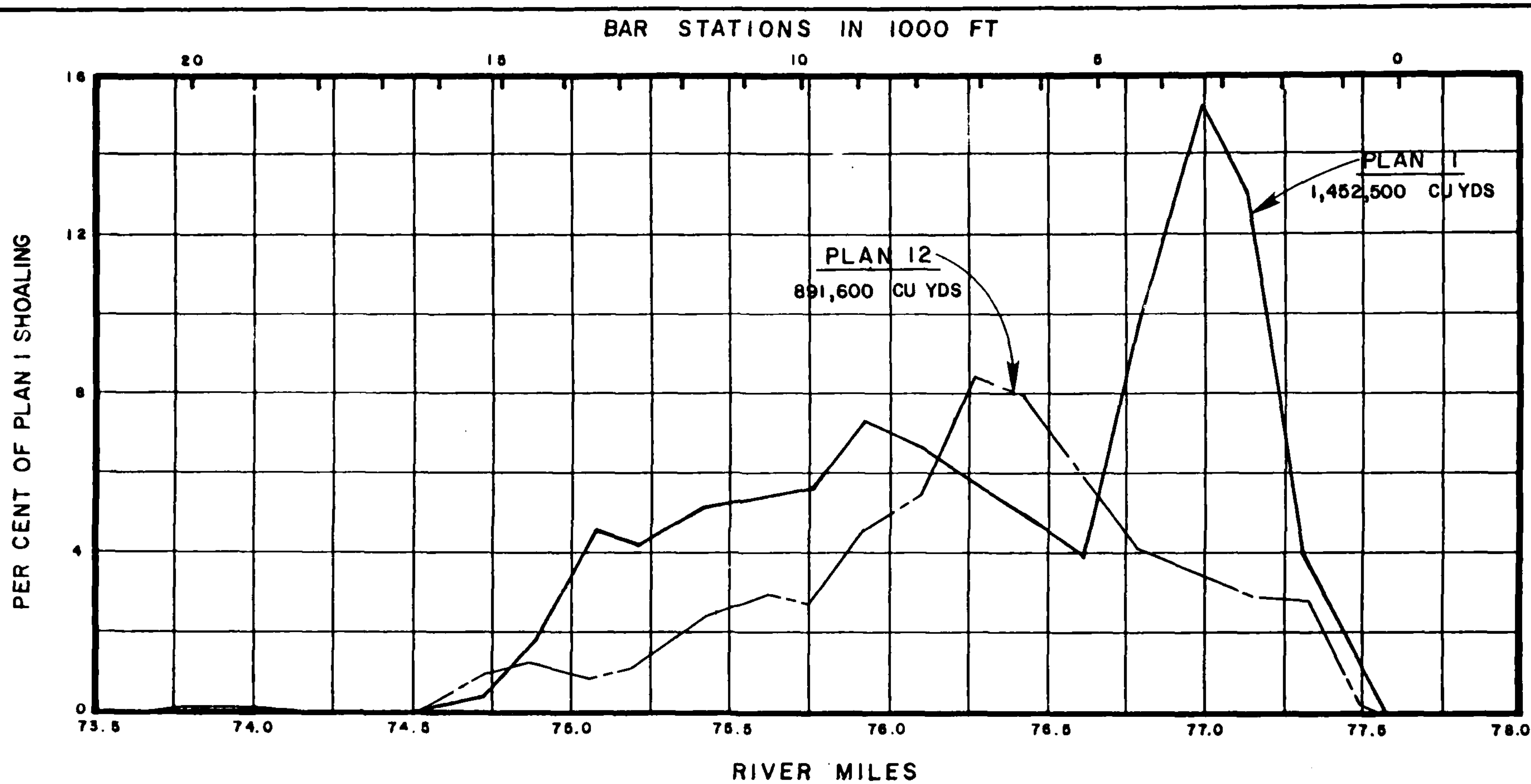
1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. DISPOSAL AREAS AND PROPOSED PILE DIKES REMAIN AS IN PLAN 11 EXCEPT AS INDICATED
3. ROCK BERM FOR DIKE 76.86 IS 15 FT WIDE, 5 FT UPSTREAM AND 10 FT DOWNSTREAM FROM PILES

40-FT CHANNEL

PLAN 12

TEST CONDITIONS

MILE 71 TO MILE 78

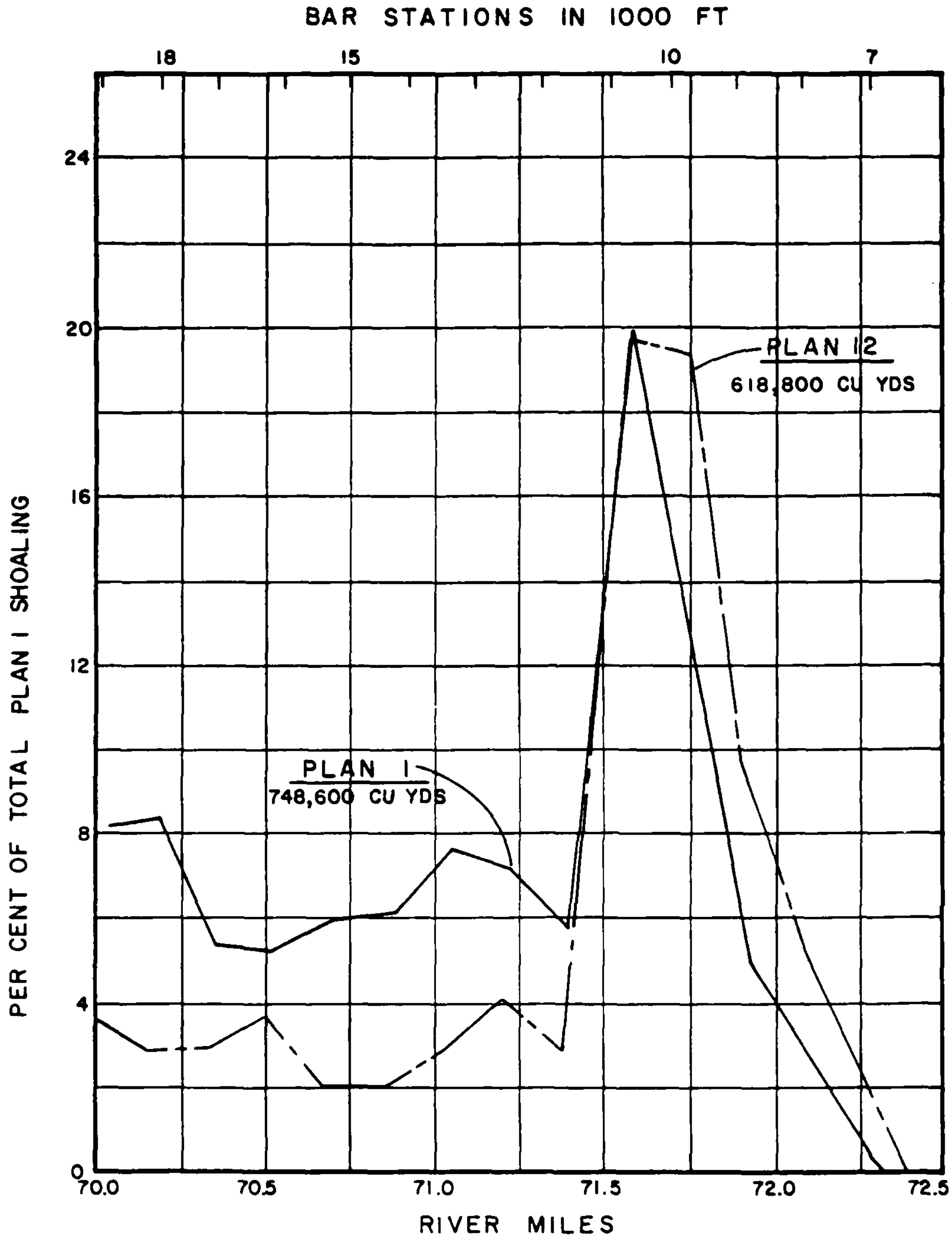


NOTE

QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40 FT PLUS 5-FT OVERDEPTH)

40-FT CHANNEL

SHOALING DISTRIBUTION
KALAMA BAR
PLANS 1 AND 12

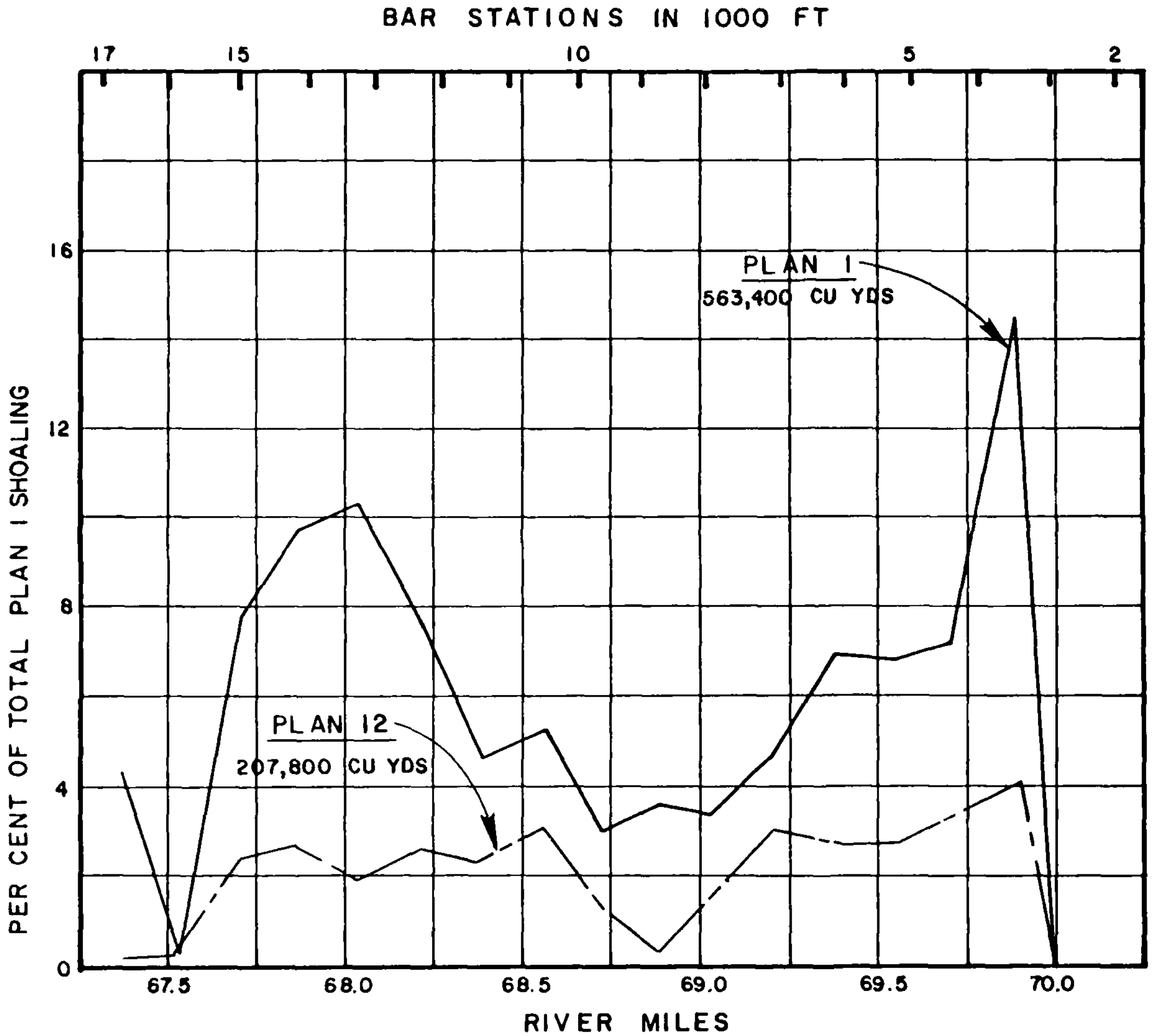


40-FT CHANNEL

NOTE

QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40 FT PLUS 5-FT OVERDEPTH).

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1 AND 12

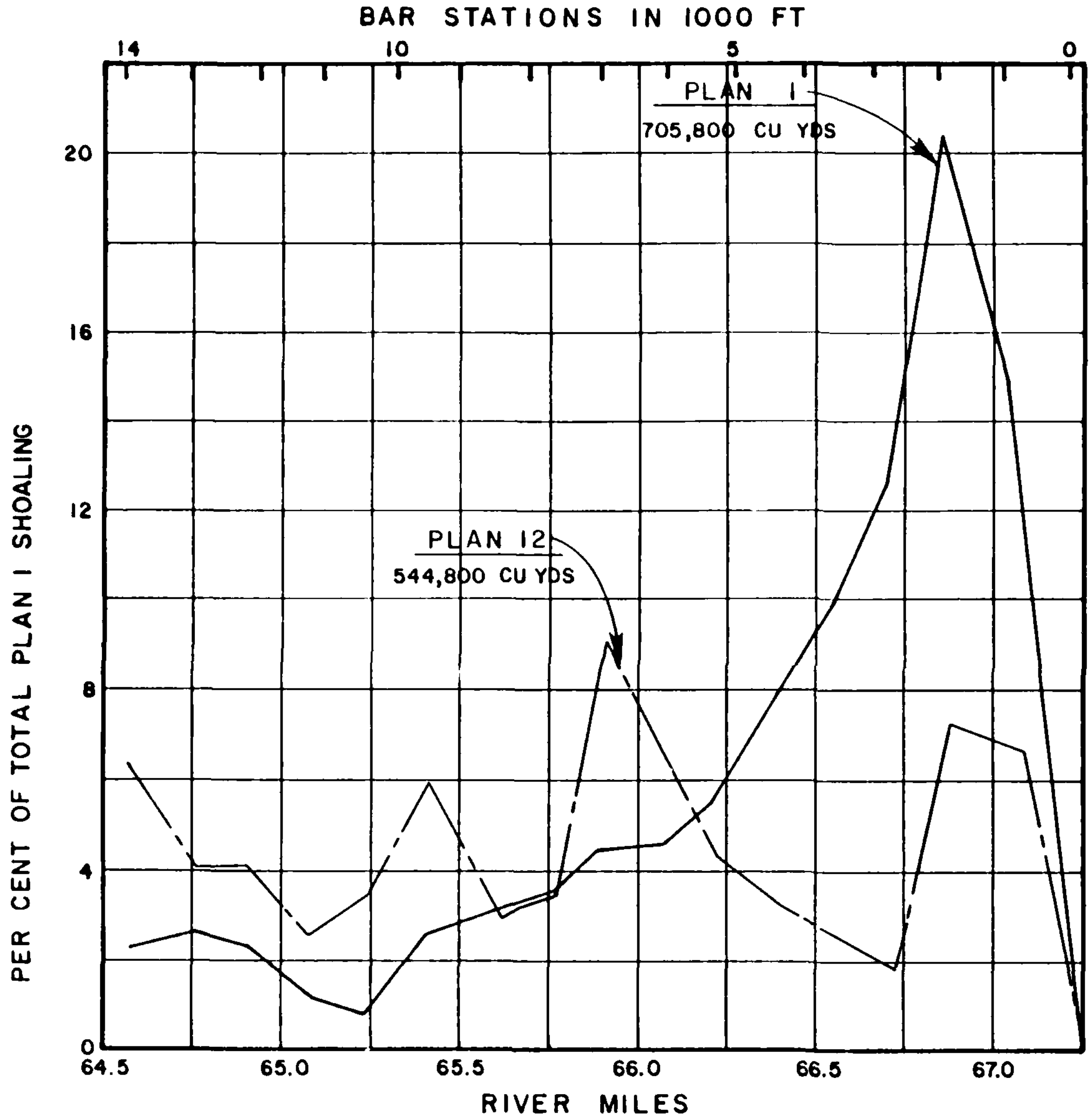


NOTE

QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION −45 CRD (40 FT PLUS 5-FT OVERDEPTH)

40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS 1 AND 12

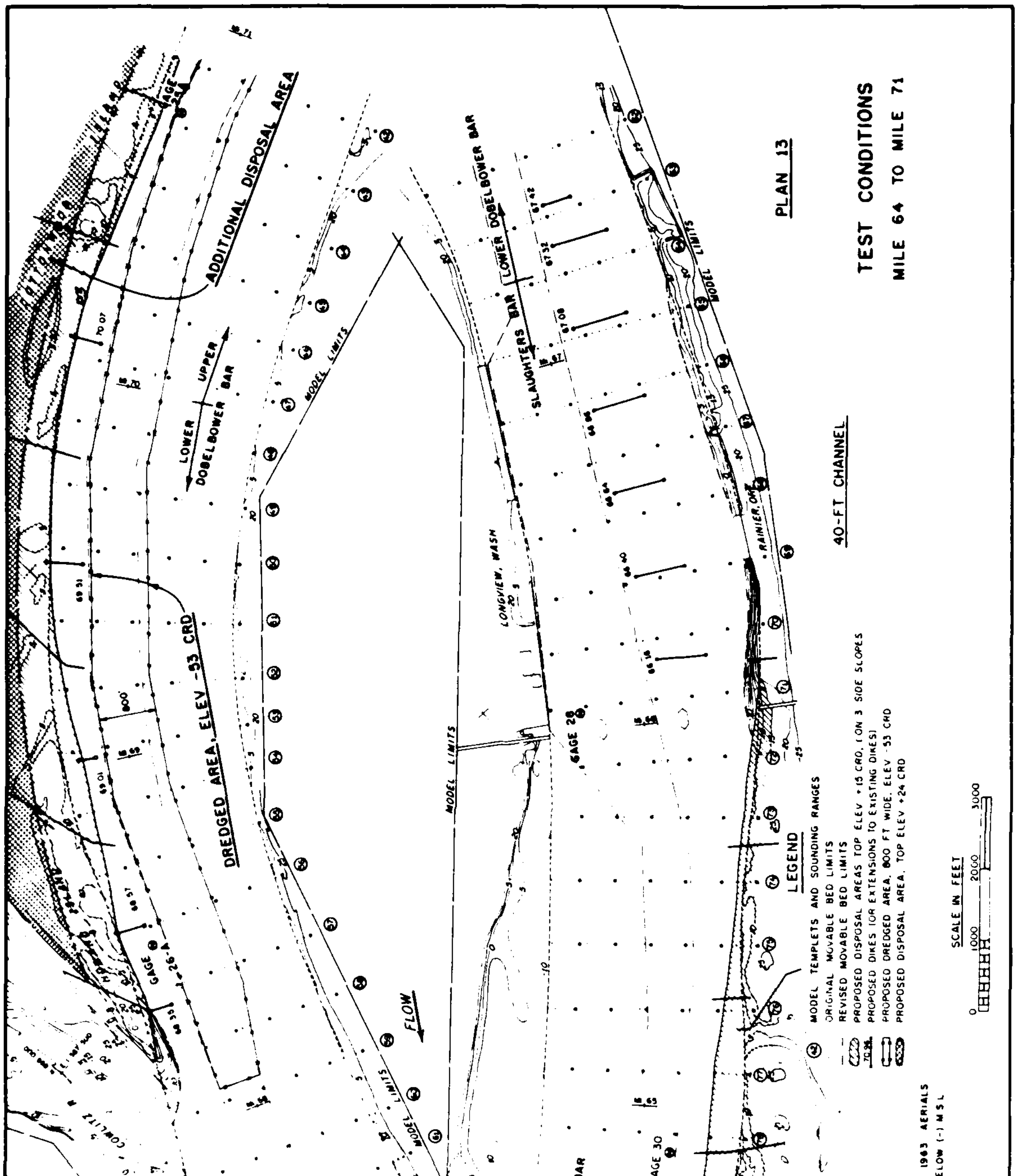


NOTE

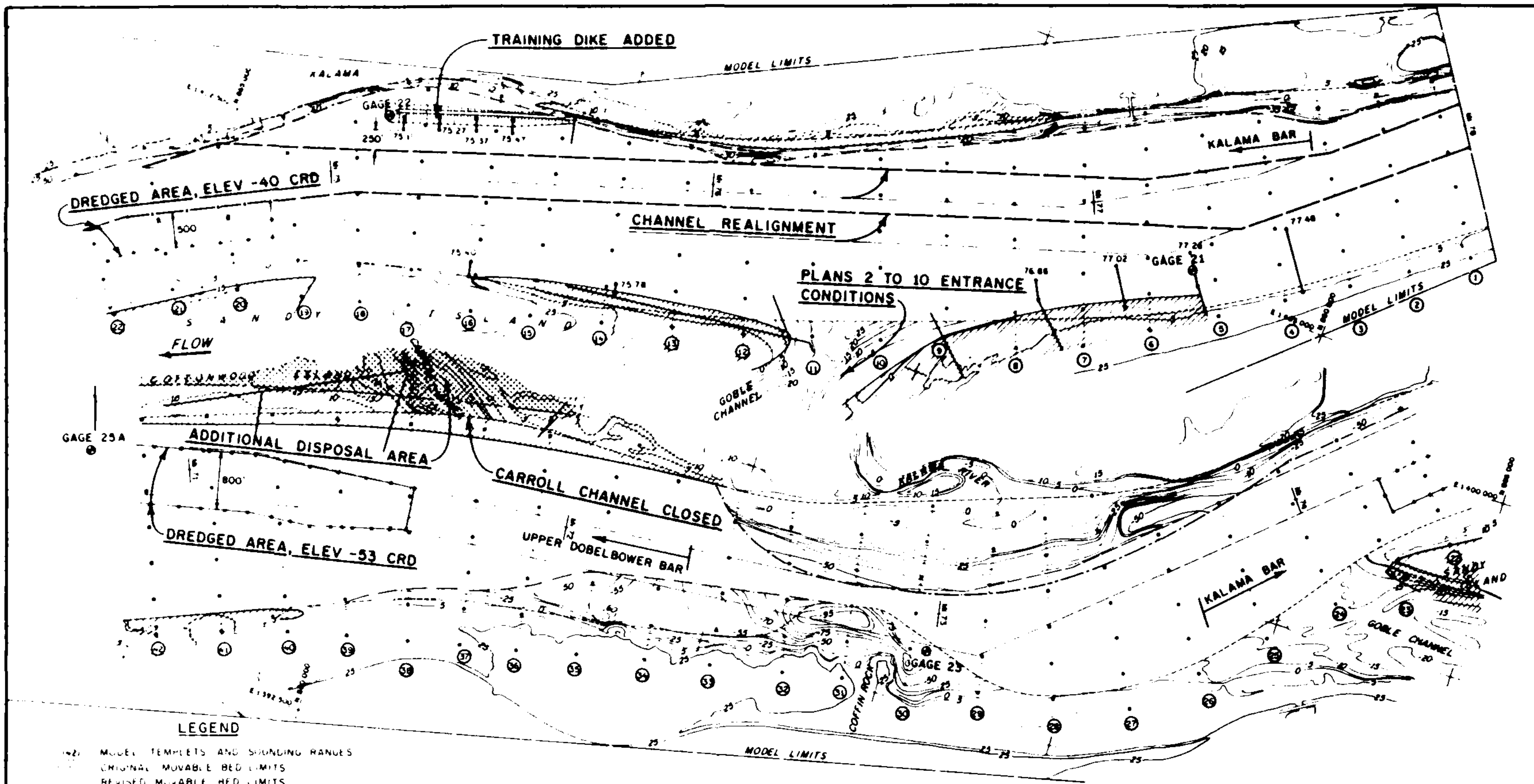
QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEVATION -45 CRD (40 FT PLUS 5-FT OVERDEPTH).

40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS 1 AND 12



PLAN 13
TEST CONDITIONS
MILE 64 TO MILE 71
40-FT CHANNEL
ADDITIONAL DISPOSAL AREA
DREDGED AREA, ELEV -53 CRD
LOWER DOBELBOWER BAR
UPPER DOBELBOWER BAR
SLAUGHTERS BAR
LONGVIEW, WASH
RAINIER, ORE
MODEL LIMITS
GAGE 26 A
GAGE 28
GAGE 30
FLOW
800
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, (ON 3 SIDE SLOPES)
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES)
PROPOSED DREDGED AREA, 800 FT WIDE, ELEV -53 CRD
PROPOSED DISPOSAL AREA, TOP ELEV +24 CRD
SCALE IN FEET
0 1000 2000 3000
NOTE
OVERBANK CONTOURS ARE BASED ON 1963 AERIALS
AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
- PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES)
- PROPOSED DREDGED AREA 500 FT WIDE, ELEV -40 CRD
- PROPOSED DREDGED AREA 800 FT WIDE, ELEV -53 CRD
- PROPOSED DISPOSAL AREA, TOP ELEV +24 CRD

SCALE IN FEET

2000 3000

NOTES

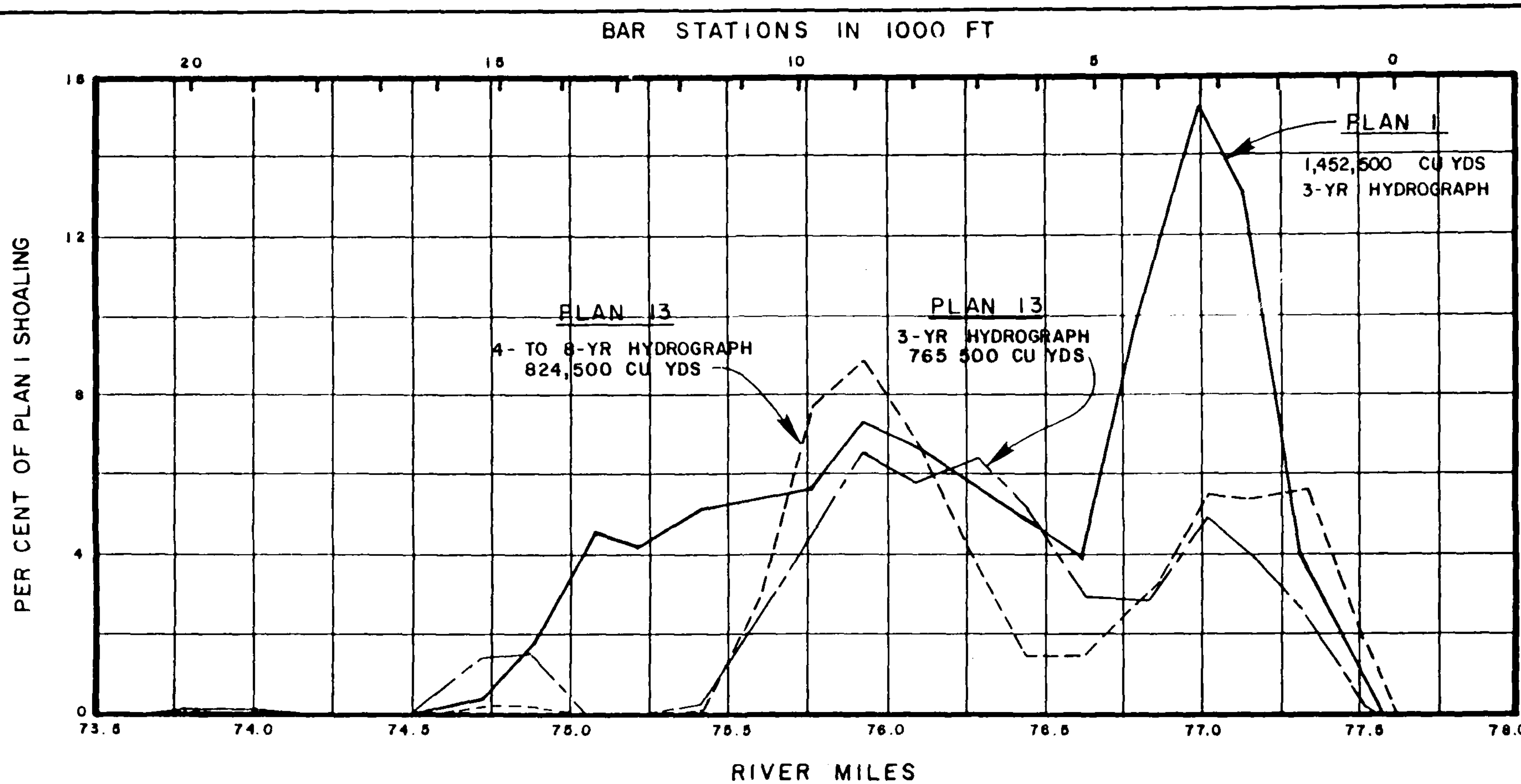
1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. DIKE 75 27 (PLAN 11) REVISED
3. DIKES 71 87 AND 72 23 (PLAN 11) ELIMINATED
4. DIKE EXTENSION 76 86 ROCKED TO ELEV -10 CRD

40-FT CHANNEL

PLAN 13

TEST CONDITIONS

MILE 71 TO MILE 78

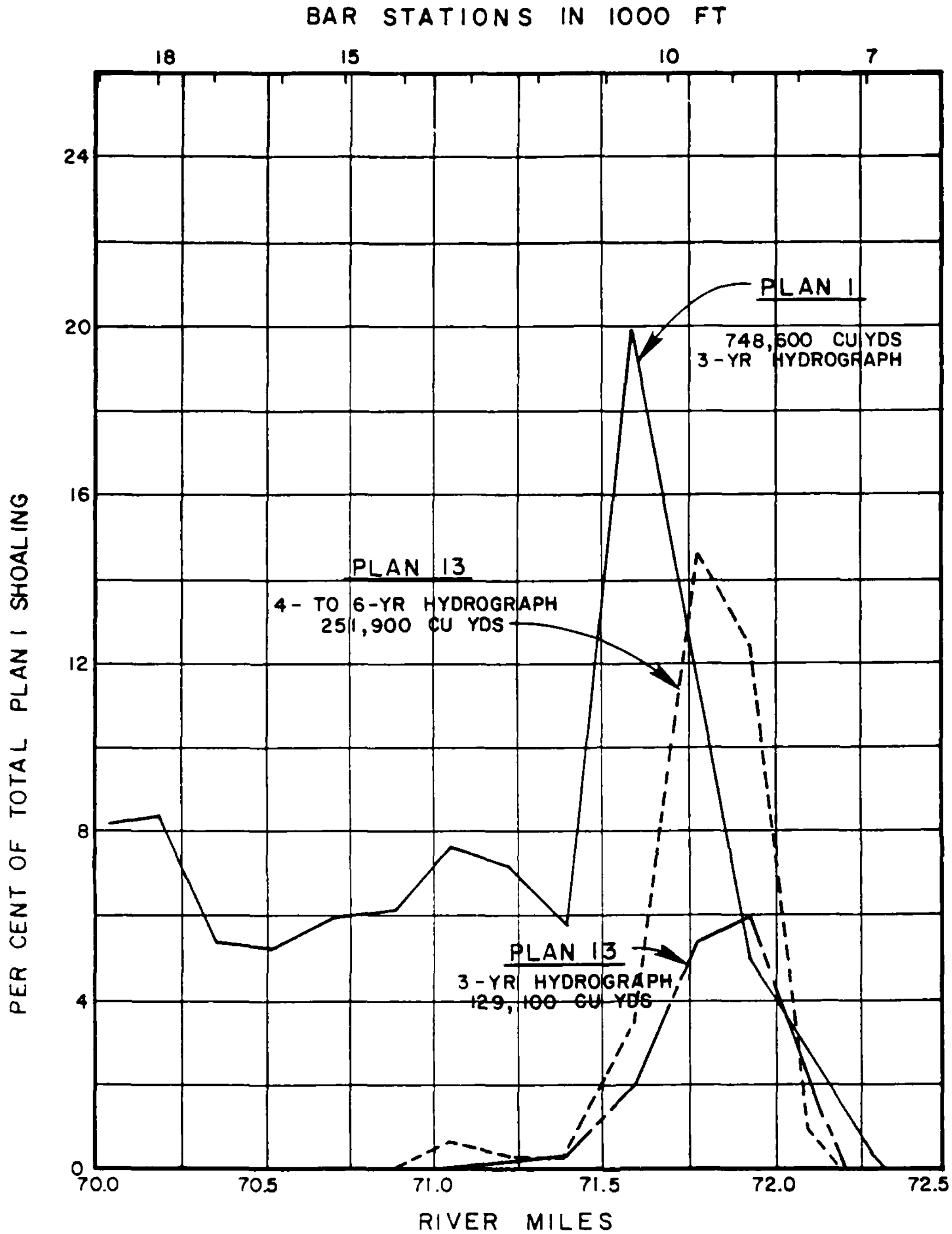


NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH.

40-FT CHANNEL

SHOALING DISTRIBUTION
KALAMA BAR
PLANS 1 AND 13

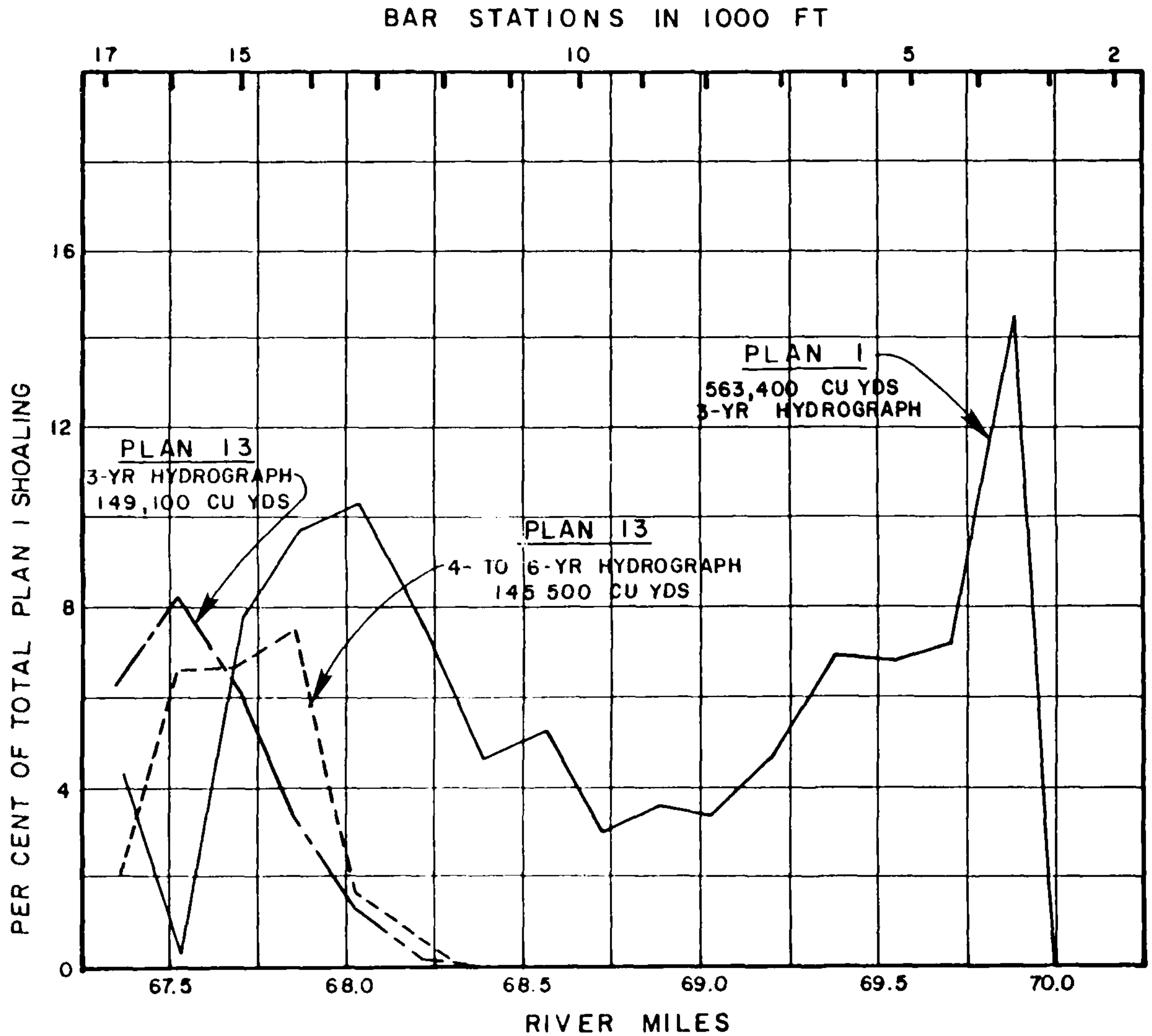


40-FT CHANNEL

NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH.

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1 AND 13

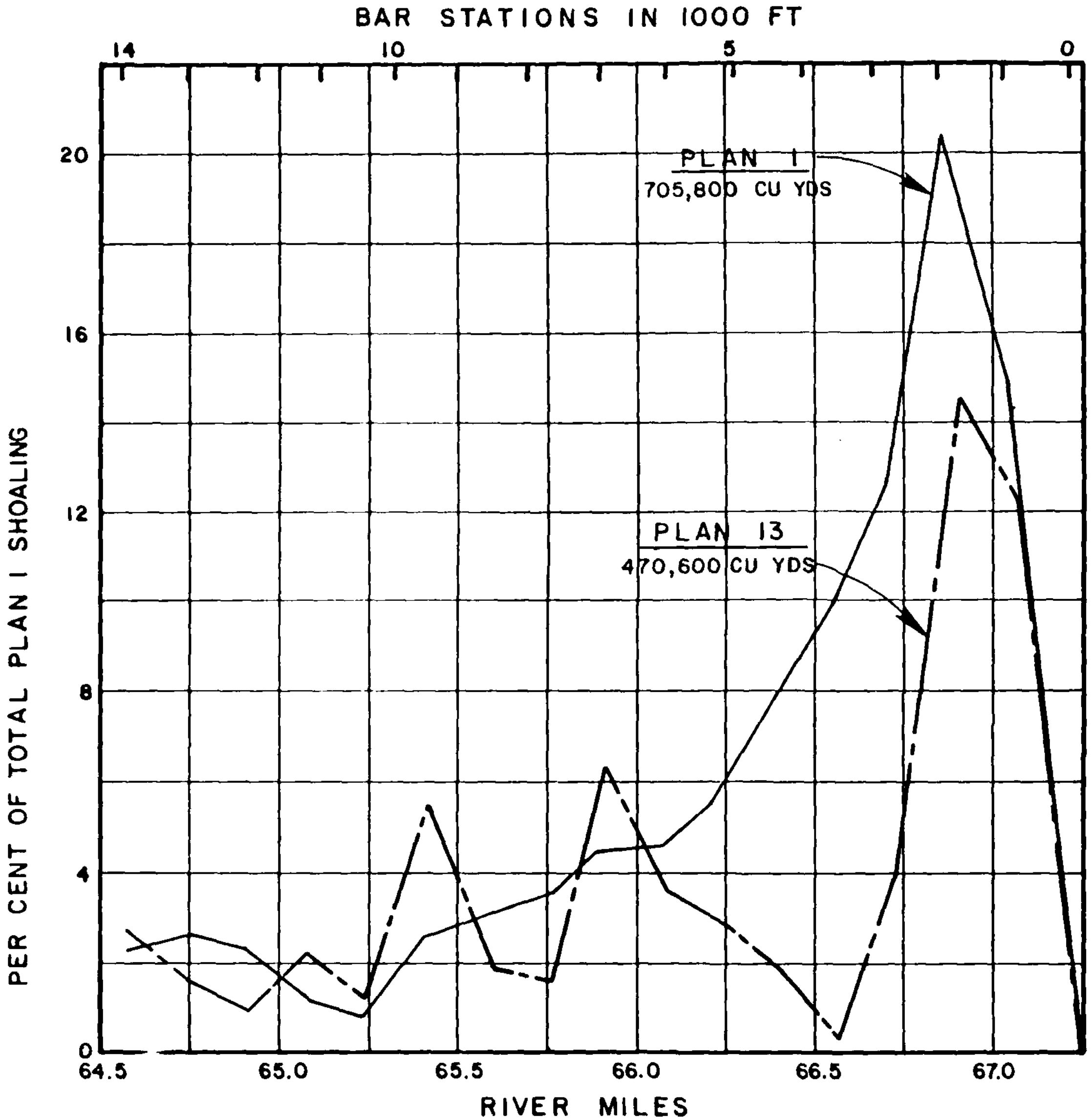


NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4 TH HYDROGRAPH.

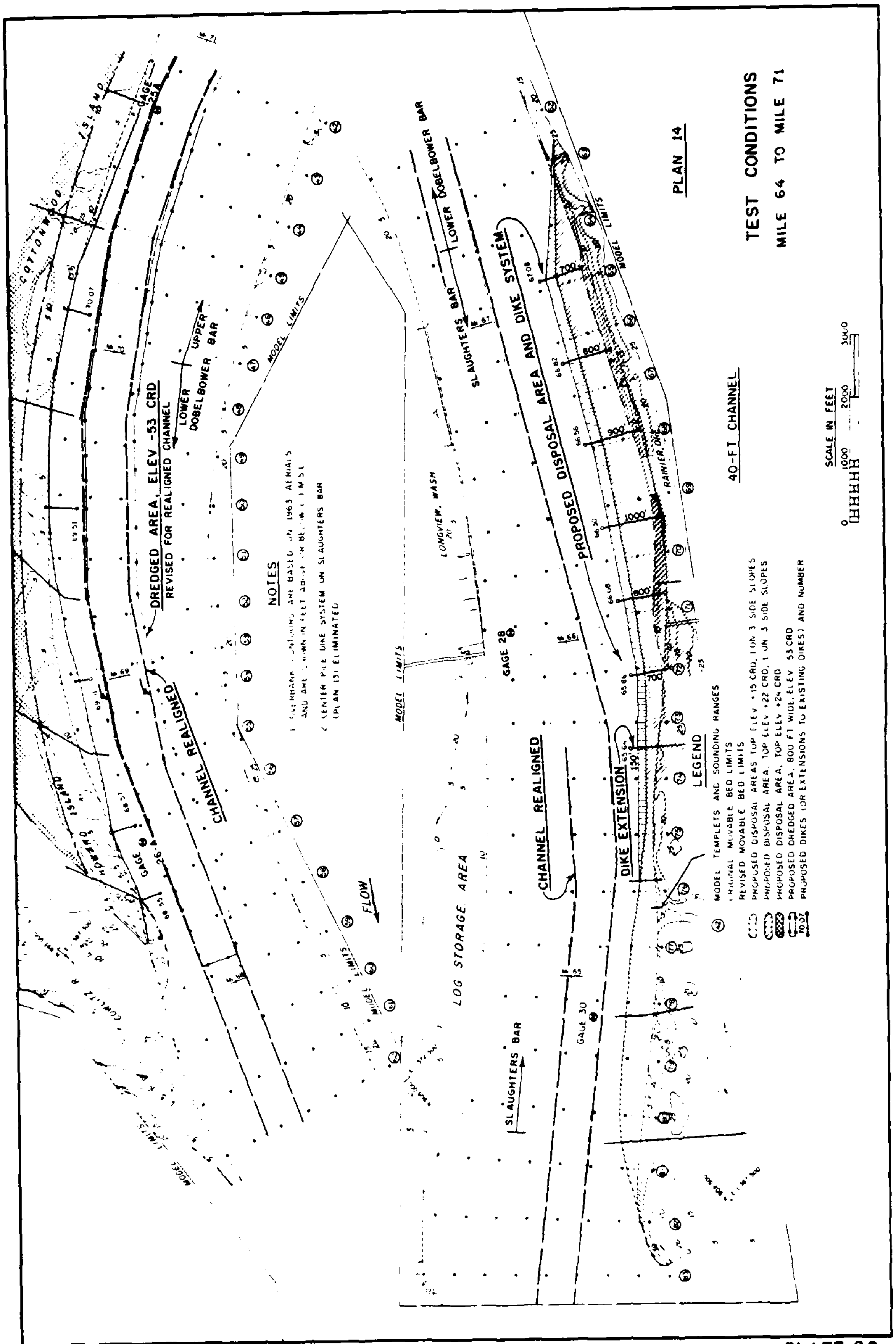
40-FT CHANNEL

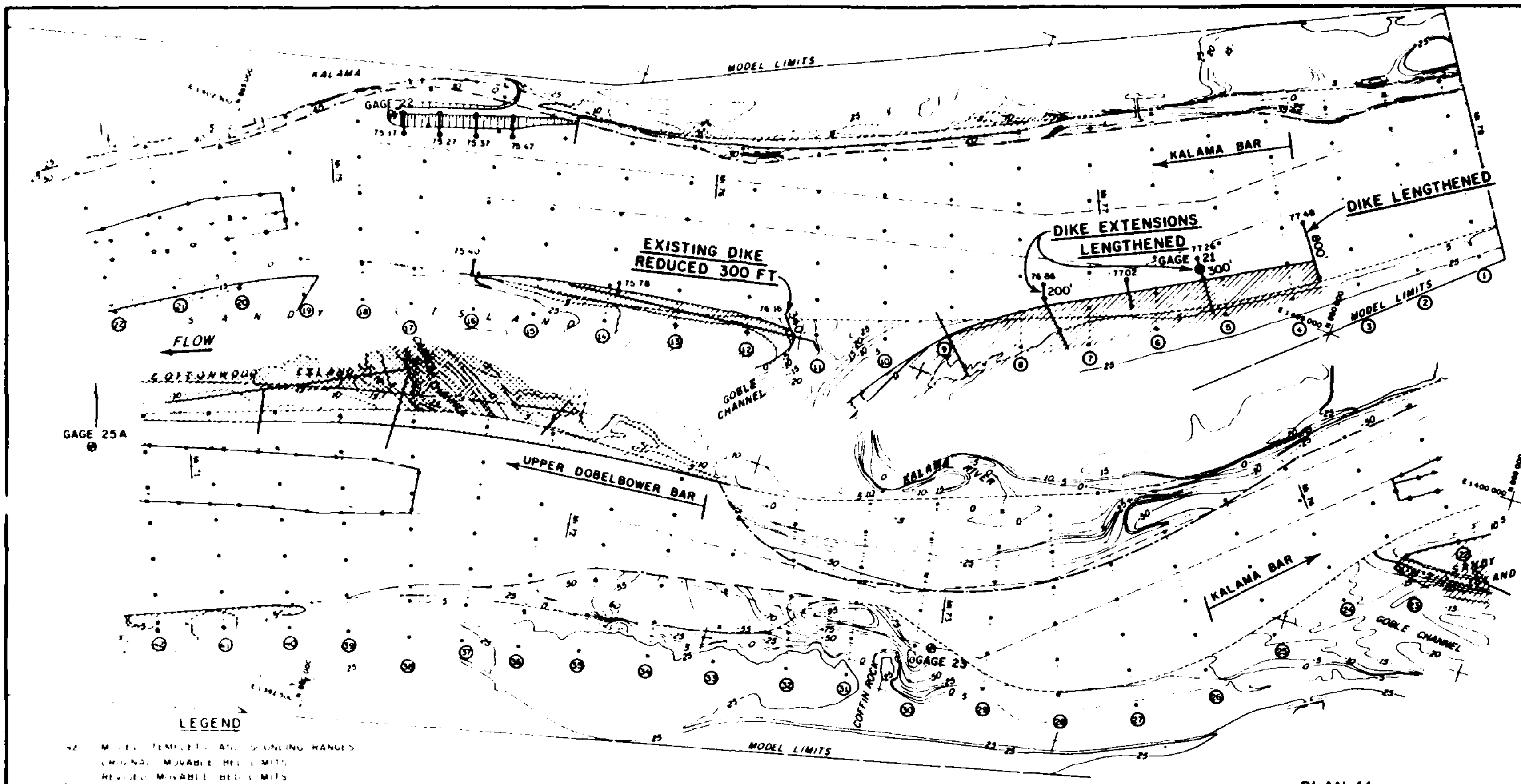
SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS I AND 13



40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS 1 AND 13


TEST CONDITIONS
MILE 64 TO MILE 71
PLAN 14
40-FT CHANNEL
SCALE IN FEET
0 1000 2000 3000
NOTES
1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW LMSL
2. CENTER PILE DIKE SYSTEM ON SLAUGHTERS BAR (PLAN 13) ELIMINATED
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
PROPOSED DISPOSAL AREA, TOP ELEV +22 CRD, 1 ON 3 SIDE SLOPES
PROPOSED DISPOSAL AREA, TOP ELEV +24 CRD
PROPOSED DREDGED AREA, 800 FT WIDE, ELEV -53 CRD
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
DREDGED AREA, ELEV -53 CRD
REVISED FOR REALIGNED CHANNEL
CHANNEL REALIGNED
PROPOSED DISPOSAL AREA AND DIKE SYSTEM
DIKE EXTENSION
COTTONWOOD ISLAND
HOWARD ISLAND
LOWER DOBELBOWER BAR
UPPER BAR
SLAUGHTERS BAR
LONGVIEW WASH
LOG STORAGE AREA
RAINIER DIKE
MODEL LIMITS
GAGE 26-A
GAGE 28
GAGE 30
FLOW
COWLITZ R



LEGEND

SCALE IN FEET

0 1000 2000 3000

40-FT CHANNEL

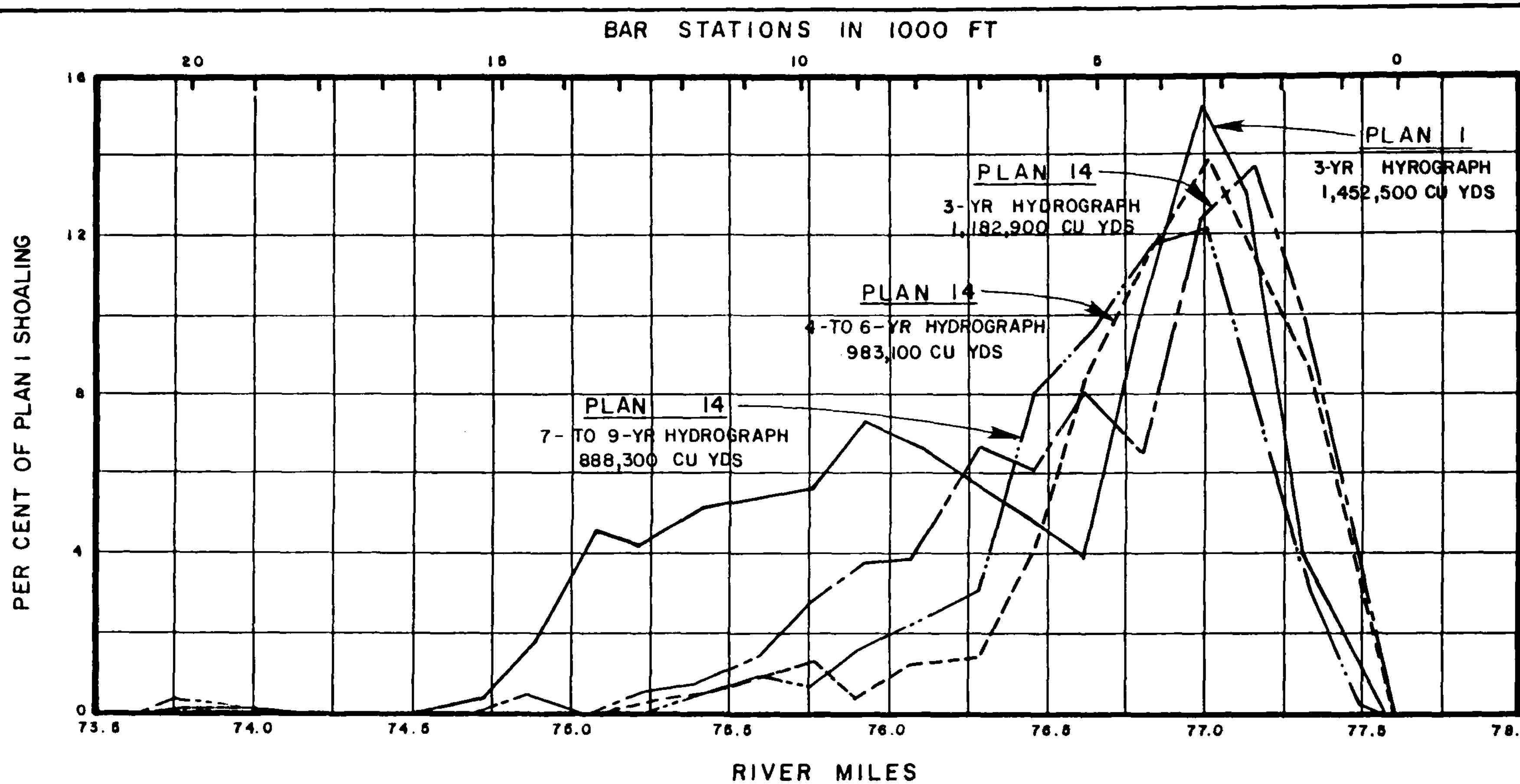
PLAN 14

TEST CONDITIONS

MILE 71 TO MILE 78

NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. ABOVE REVISIONS MADE PRIOR TO THE 7TH HYDROGRAPH

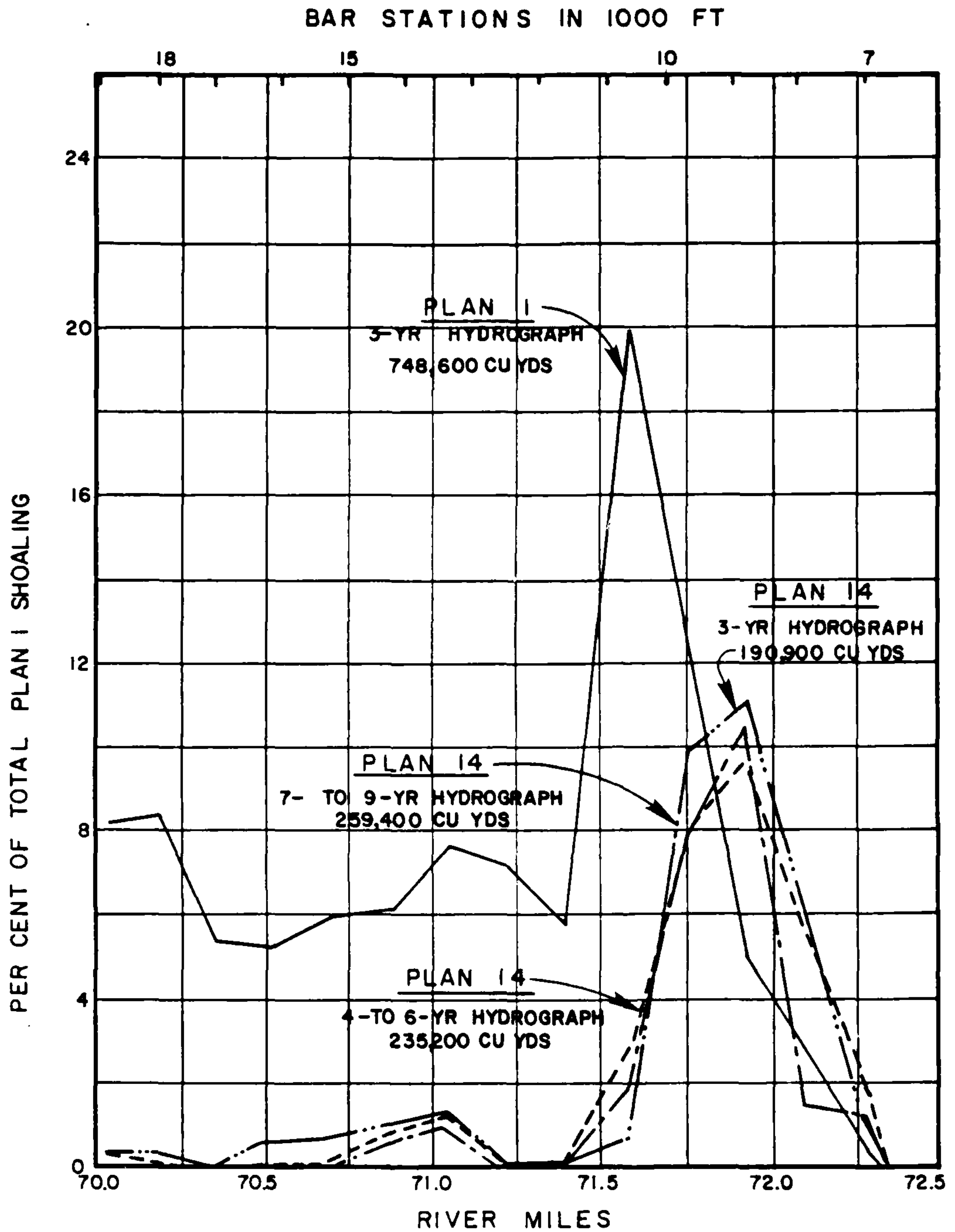


SHOALING DISTRIBUTION
KALAMA BAR
PLANS I AND 14

40-FT CHANNEL

NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS.

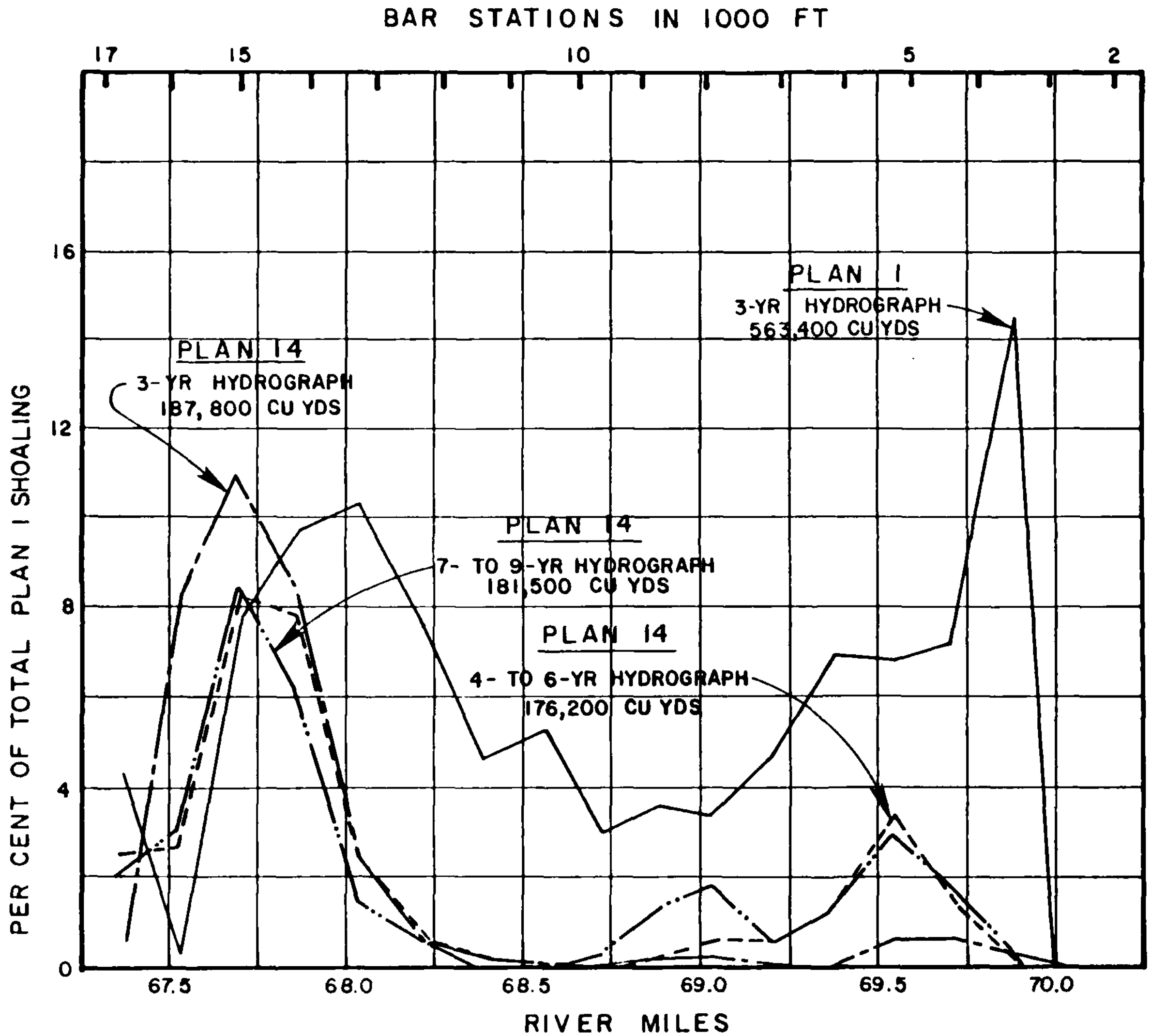


40-FT CHANNEL

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS I AND 14

NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS.

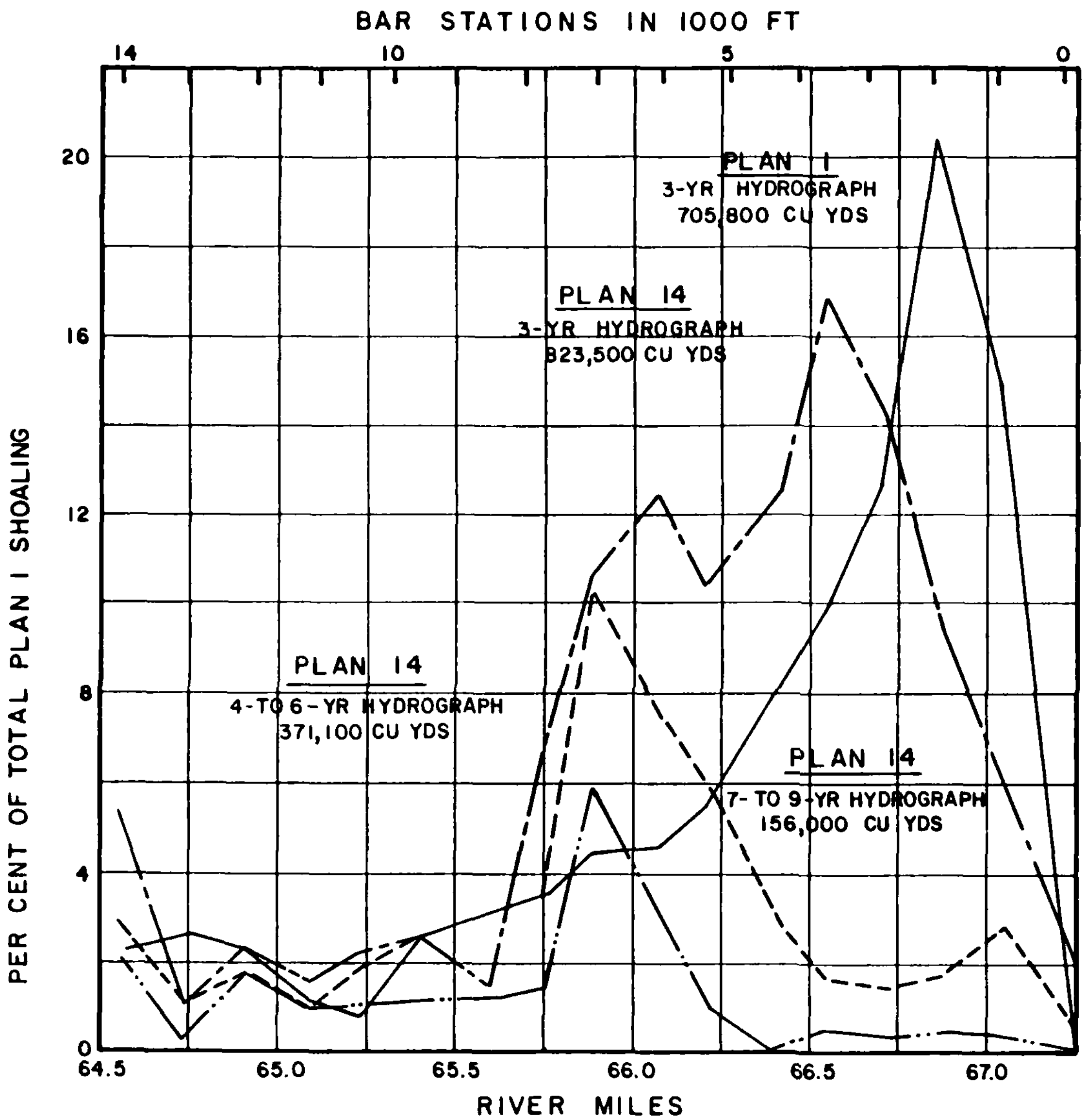


NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7 TH HYDROGRAPH.

40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS I AND 14

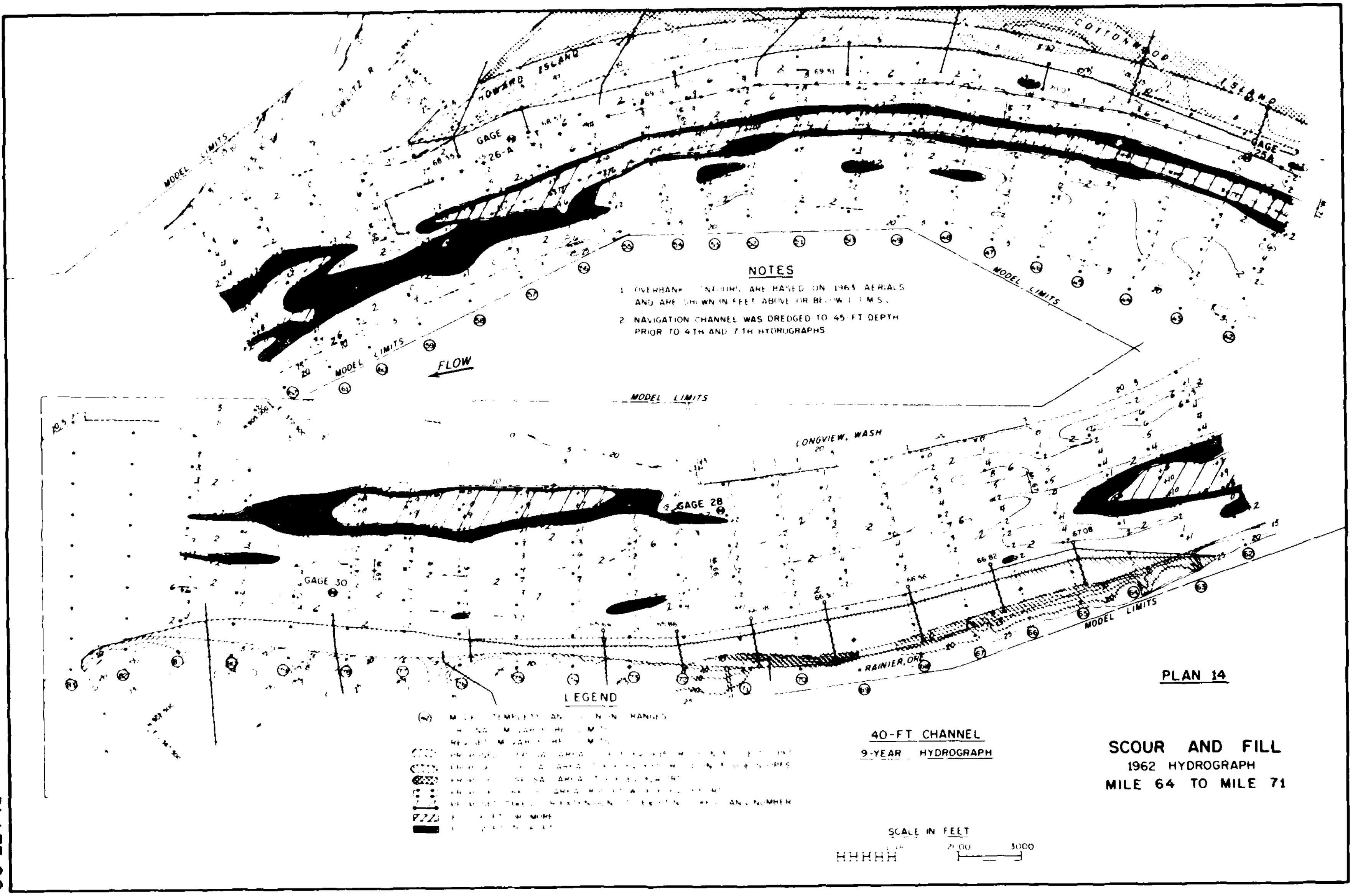


NOTE

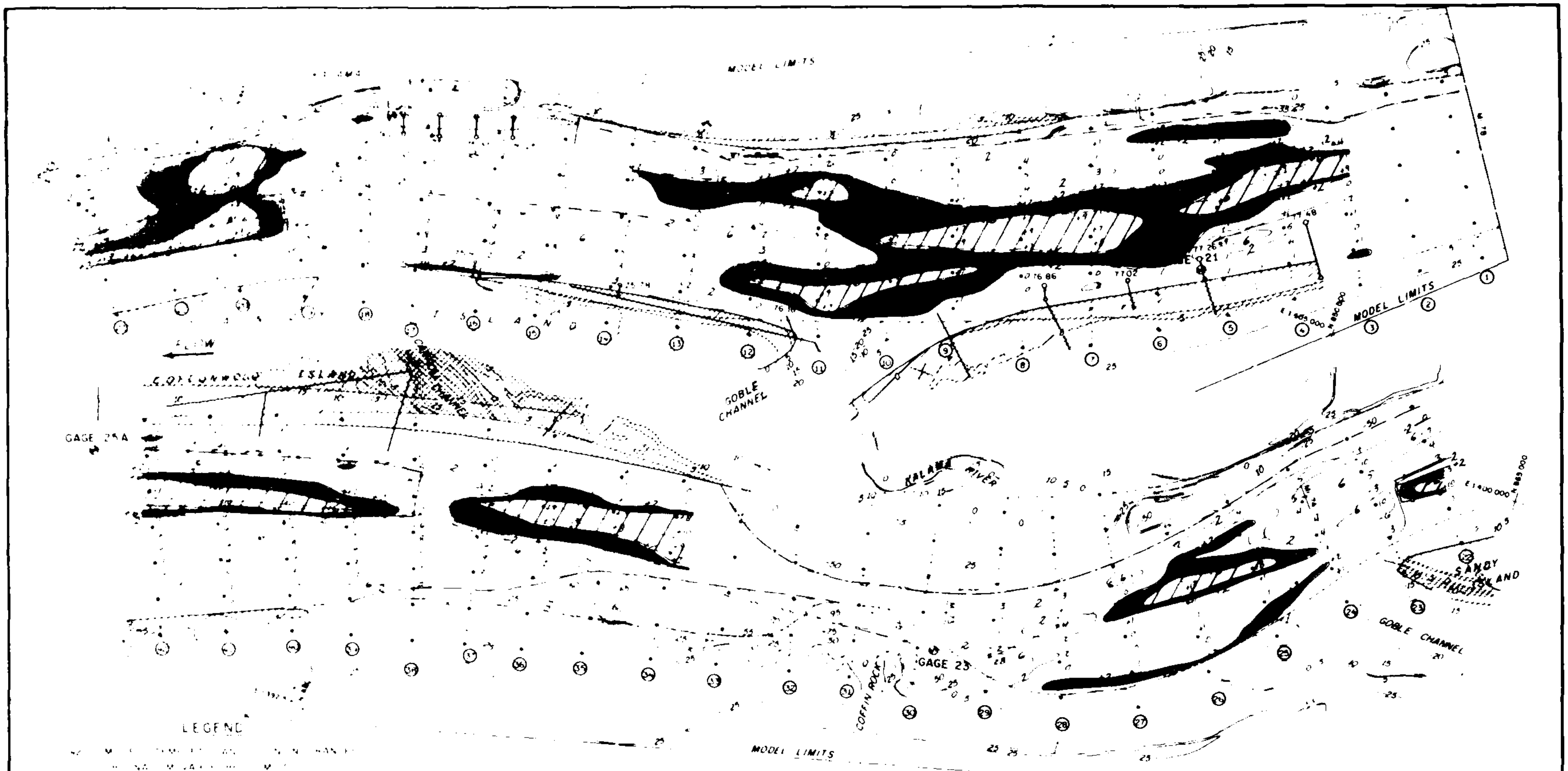
NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS.

40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS I AND 14



SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71
PLAN 14
40-FT CHANNEL
9-YEAR HYDROGRAPH
NOTES
2. NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS
LEGEND
SCALE IN FEET
3000
FLOW
MODEL LIMITS
COTTONWOOD ISLAND
HOWARD ISLAND
COWLITZ R
LONGVIEW, WASH
RAINIER, ORE
GAGE 25A
GAGE 26-A
GAGE 28
GAGE 30



PLAN 14

SCALE IN FEET

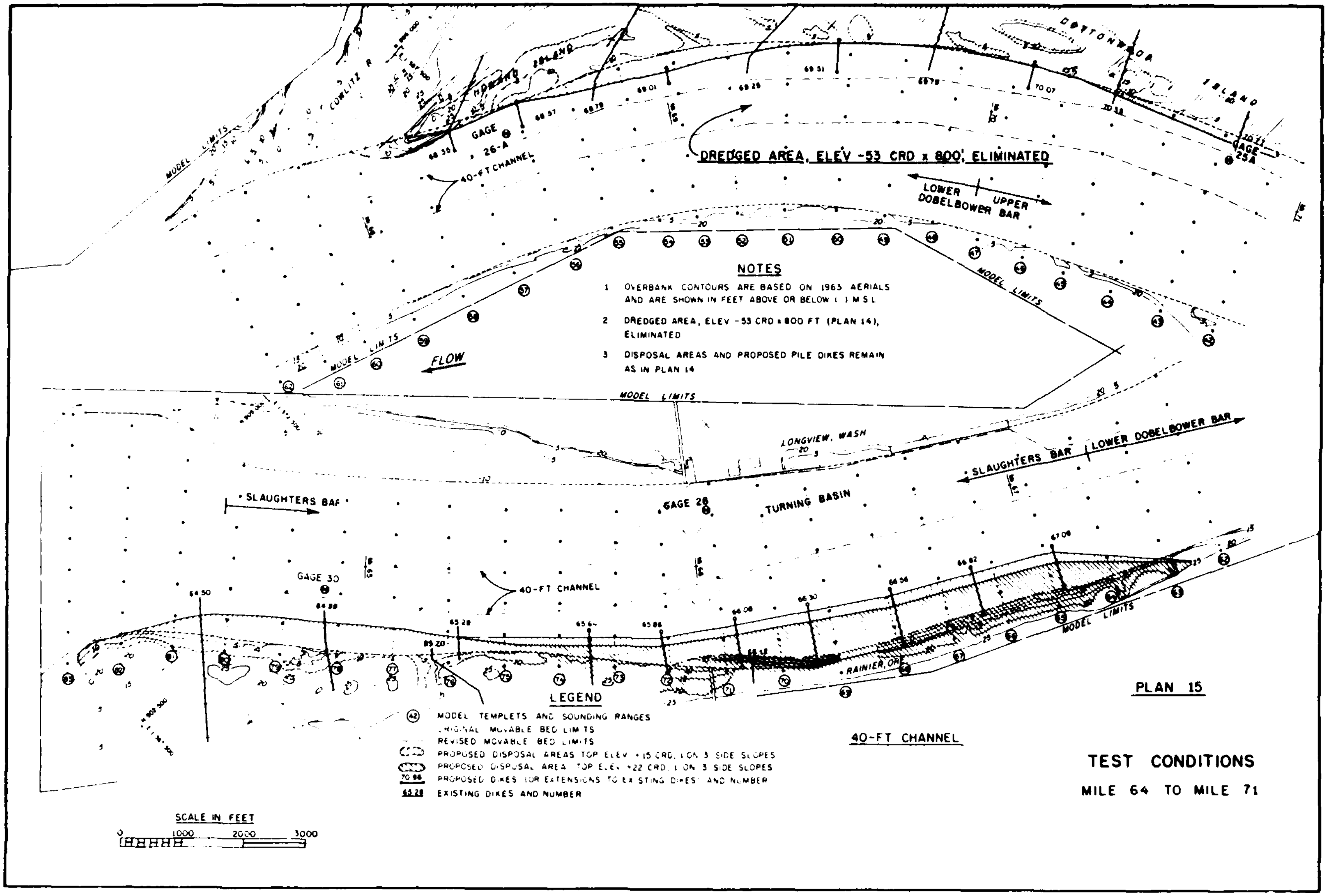
0 1000 2000 3000

40-FT CHANNEL
9-YEAR HYDROGRAPH

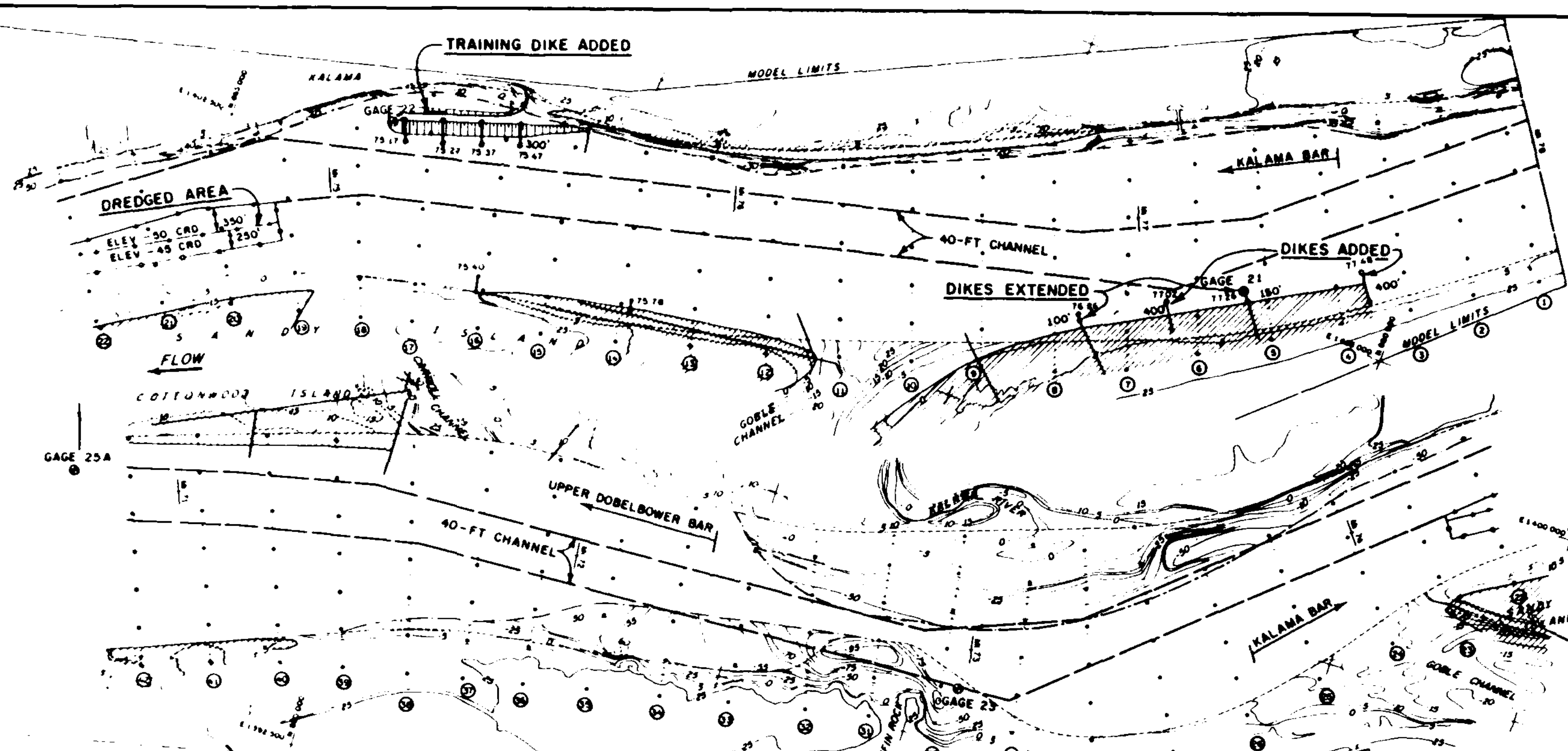
SCOUR AND FILL
1962 HYDROGRAPH
MILE 71 TO MILE 78

NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M.S.L.
2. NAVIGATION CHANNEL WAS DREDGED TO 45 FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS



DREDGED AREA, ELEV -53 CRD x 800' ELIMINATED
LOWER DOBELBOWER BAR
UPPER DOBELBOWER BAR
COTTONWOOD ISLAND
HOWARD ISLAND
COWLITZ R
GAGE 26-A
GAGE 25A
40-FT CHANNEL
MODEL LIMITS
FLOW
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW ( ) M S L
2 DREDGED AREA, ELEV -53 CRD x 800 FT (PLAN 14), ELIMINATED
3 DISPOSAL AREAS AND PROPOSED PILE DIKES REMAIN AS IN PLAN 14
LONGVIEW, WASH
SLAUGHTERS BAR
LOWER DOBELBOWER BAR
SLAUGHTERS BAR
GAGE 28
TURNING BASIN
GAGE 30
40-FT CHANNEL
RAINIER, ORE
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
PROPOSED DISPOSAL AREA TOP ELEV +22 CRD, 1 ON 3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
EXISTING DIKES AND NUMBER
SCALE IN FEET
0 1000 2000 3000
PLAN 15
40-FT CHANNEL
TEST CONDITIONS
MILE 64 TO MILE 71



LEGEND

- (42) MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD (ON 3 SIDE SLOPES)
- PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
- PROPOSED DREDGED AREA ELEV -45 CRD
- PROPOSED DREDGED AREA ELEV -50 CRD

SCALE IN FEET

0 1000 2000 3000

40-FT CHANNEL

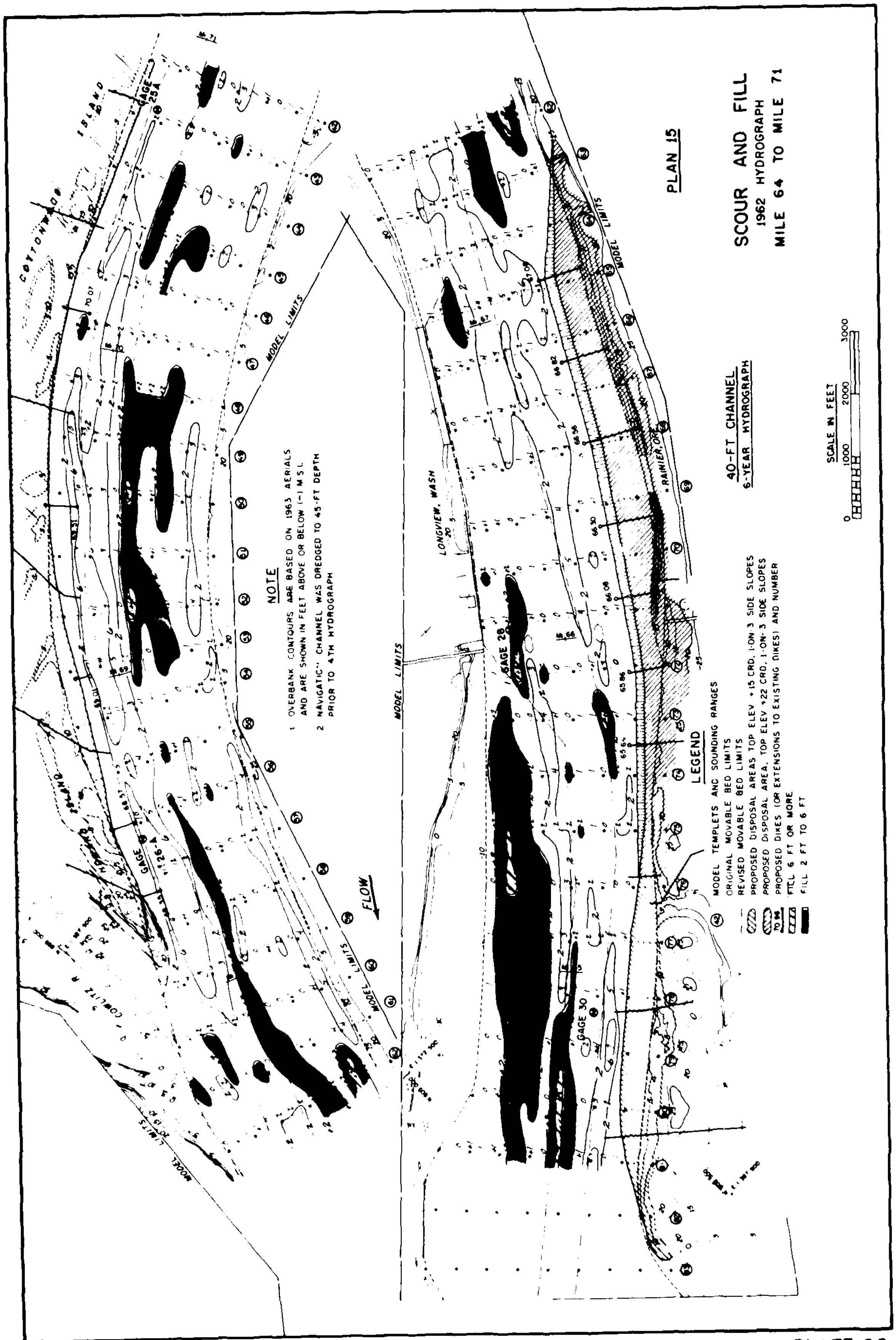
PLAN 15

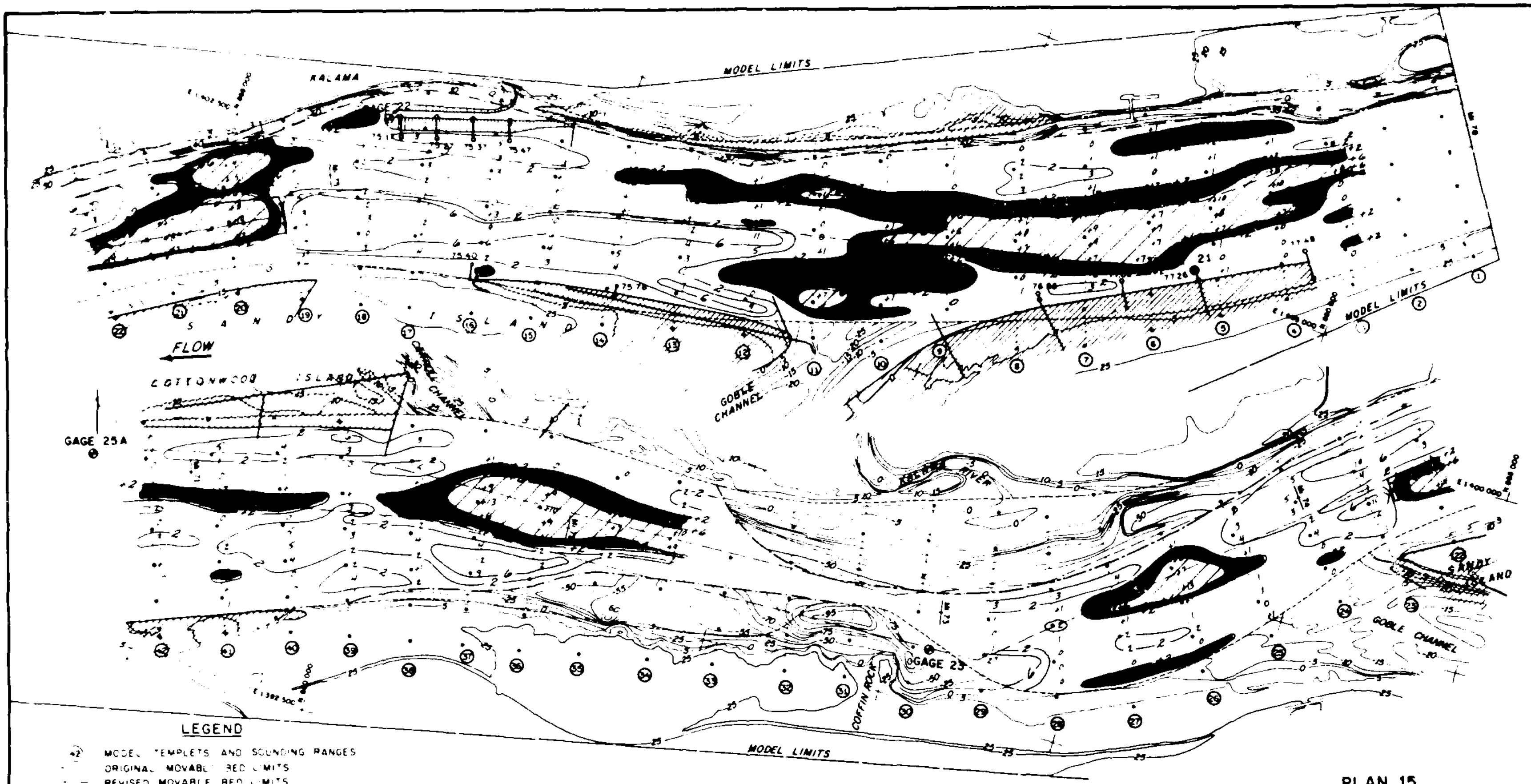
NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2. DIKES 76.86, 77.26, AND 77.48 AS IN INITIAL STAGES OF PLAN 14
3. CARROLL CHANNEL OPEN, AND THE DREDGED AREA, ELEV -53 CRD x 800 FT (PLAN 14), ELIMINATED

TEST CONDITIONS

MILE 71 TO MILE 78


PLAN 15
SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71
40-FT CHANNEL
6-YEAR HYDROGRAPH
SCALE IN FEET
0 1000 2000 3000
NOTE
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2 NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DISPOSAL AREA, TOP ELEV +22 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
COTTONWOOD ISLAND
GAGE 25A
GAGE 26A
GAGE 28
GAGE 30
LONGVIEW, WASH
RAINIER, ORE
COWLITZ R
FLOW
MODEL LIMITS



LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
- PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
- PROPOSED DREDGED AREA ELEV -45 CRD
- PROPOSED DREDGED AREA ELEV -50 CRD
- FILL 6 FT OR MORE
- FILL 2 FT TO 6 FT

SCALE IN FEET

1000 2000 3000

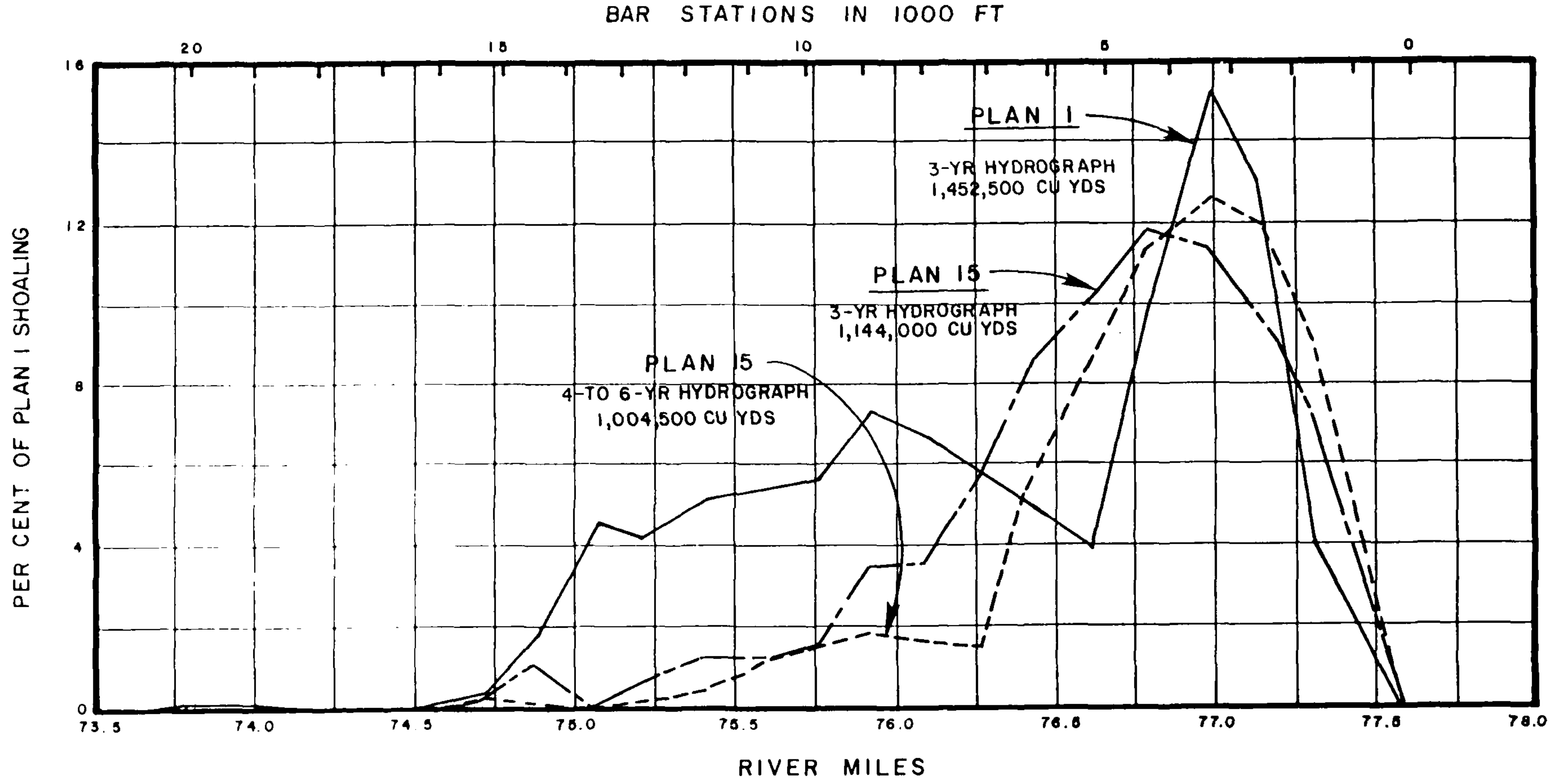
NOTES

1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2 NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH

40-FT CHANNEL
6-YEAR HYDROGRAPH

PLAN 15

SCOUR AND FILL
1962 HYDROGRAPH
MILE 71 TO MILE 78

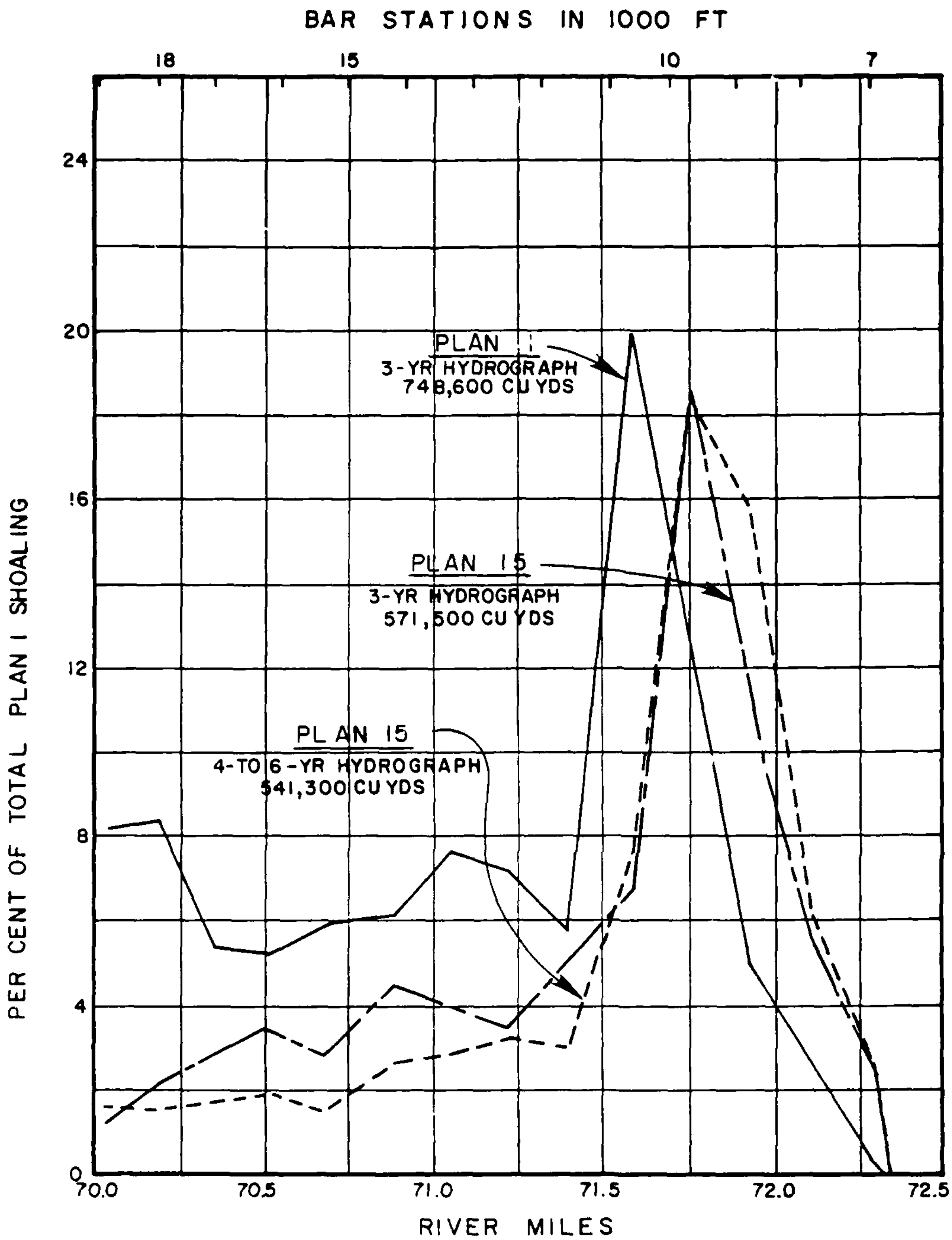


NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4 TH HYDROGRAPH.

40-FT CHANNEL

SHOALING DISTRIBUTION
KALAMA BAR
PLANS I AND 15

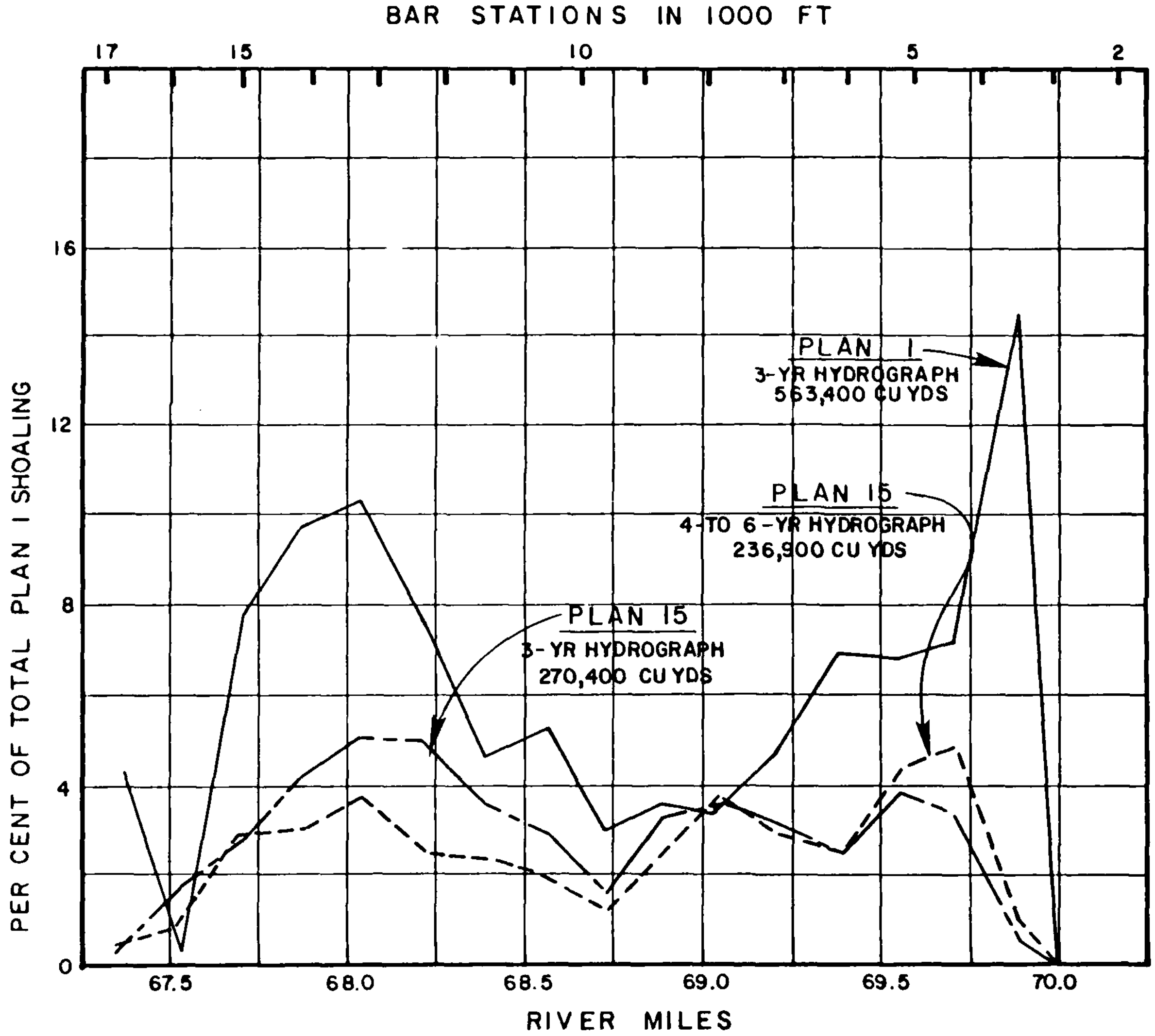


40-FT CHANNEL

NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4 TH HYDROGRAPH

SHOALING DISTRIBUTION
UPPER DOBELBOWER BAR
PLANS 1 AND 15

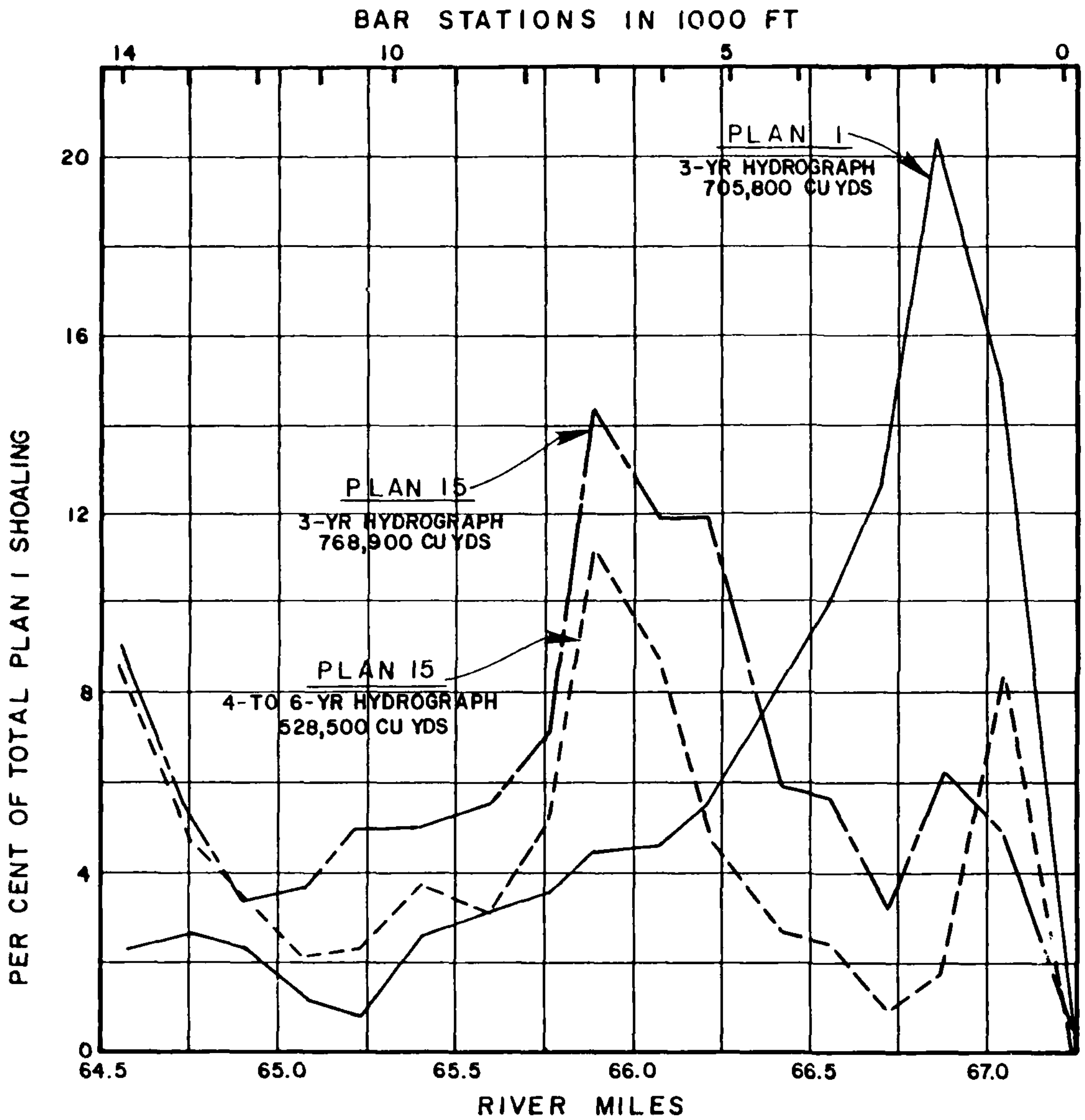


NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH

40-FT CHANNEL

SHOALING DISTRIBUTION
LOWER DOBELBOWER BAR
PLANS I AND 15

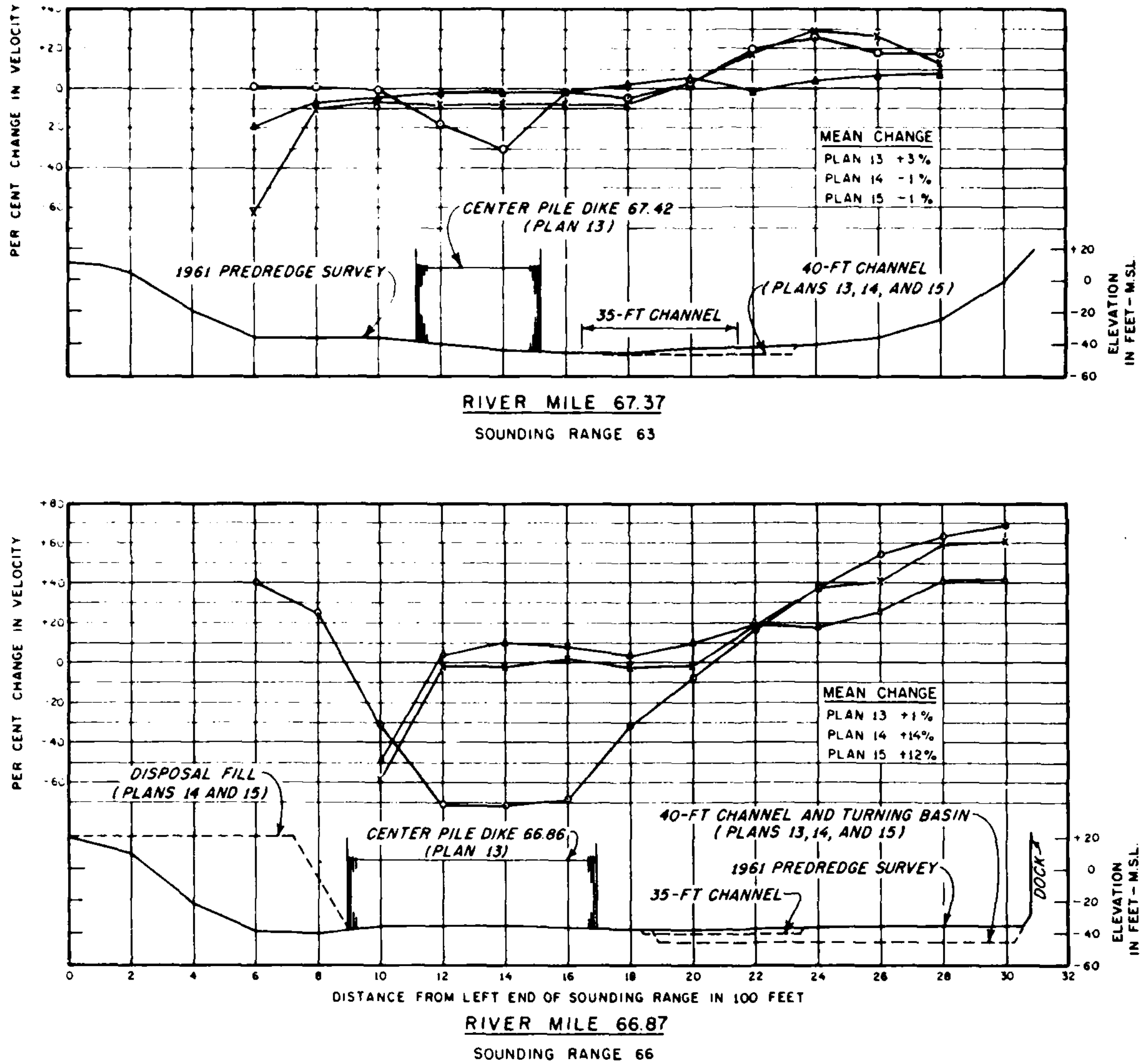


NOTE

NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH HYDROGRAPH.

40-FT CHANNEL

SHOALING DISTRIBUTION
SLAUGHTERS BAR
PLANS I AND 15



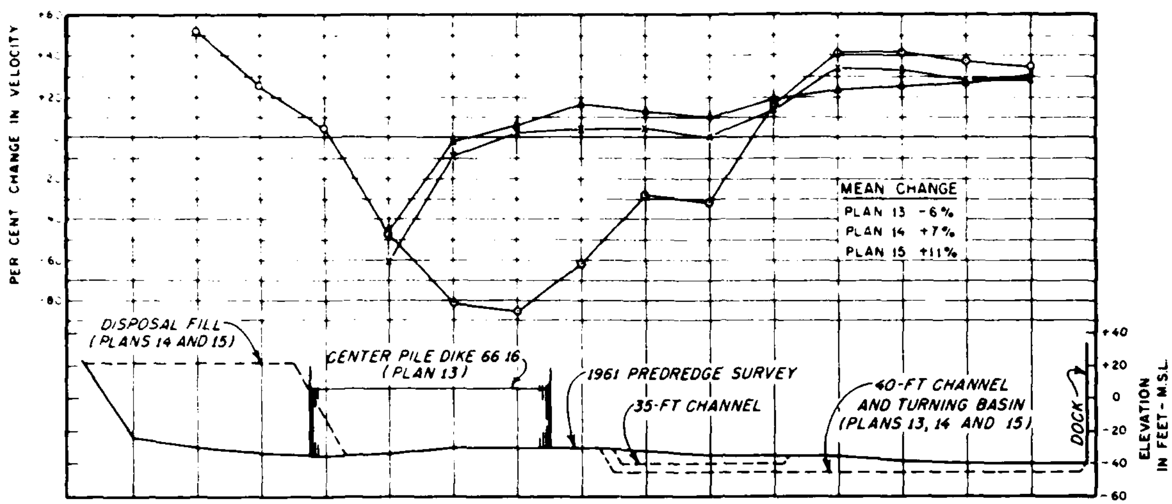
NOTES

1. VELOCITIES WERE MEASURED AT 15-FT DEPTH
2. CHANGE IN VELOCITY IS SHOWN IN PER CENT OF 35-FT CHANNEL VELOCITIES.
3. PERCENTAGES ARE AVERAGES OF SIMULATED FRESH WATER DISCHARGES OF 338 000 CFS AND 450 000 CFS

LEGEND

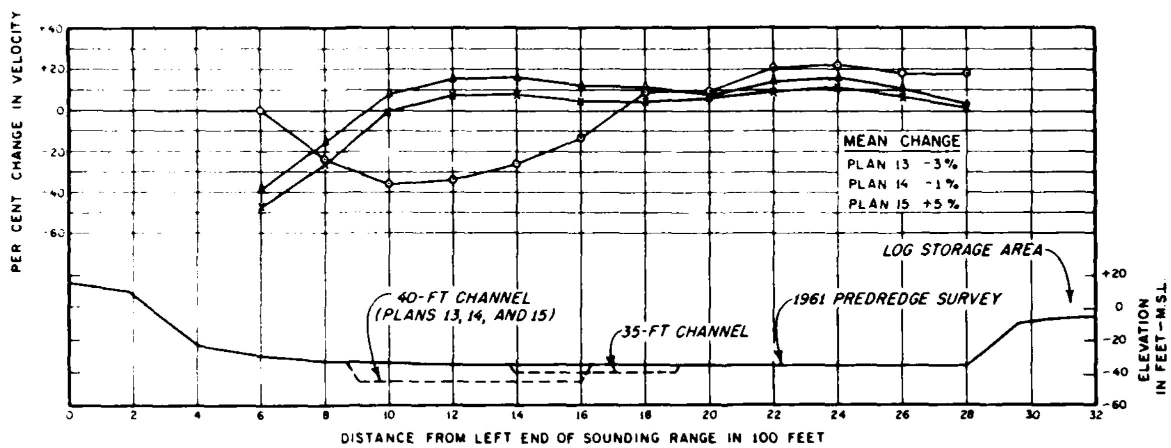
—o— PLAN 13
—x— PLAN 14
—Δ— PLAN 15

PER CENT CHANGE IN VELOCITIES
35-FT CHANNEL VS 40-FT CHANNEL
SLAUGHTERS BAR
RIVER MILES 67.37 AND 66.87
PLANS 13, 14, AND 15



RIVER MILE 66.22

SOUNDING RANGE 70



RIVER MILE 65.60

SOUNDING RANGE 74

NOTES

1 VELOCITIES WERE MEASURED AT 15-FT DEPTH
2 CHANGE IN VELOCITY IS SHOWN IN PER CENT OF 35-FT CHANNEL VELOCITIES
3 PERCENTAGES ARE AVERAGES OF SIMULATED FRESH WATER DISCHARGES OF 338 000 CFS AND 450 000 CFS

LEGEND

PLAN 13
PLAN 14
PLAN 15

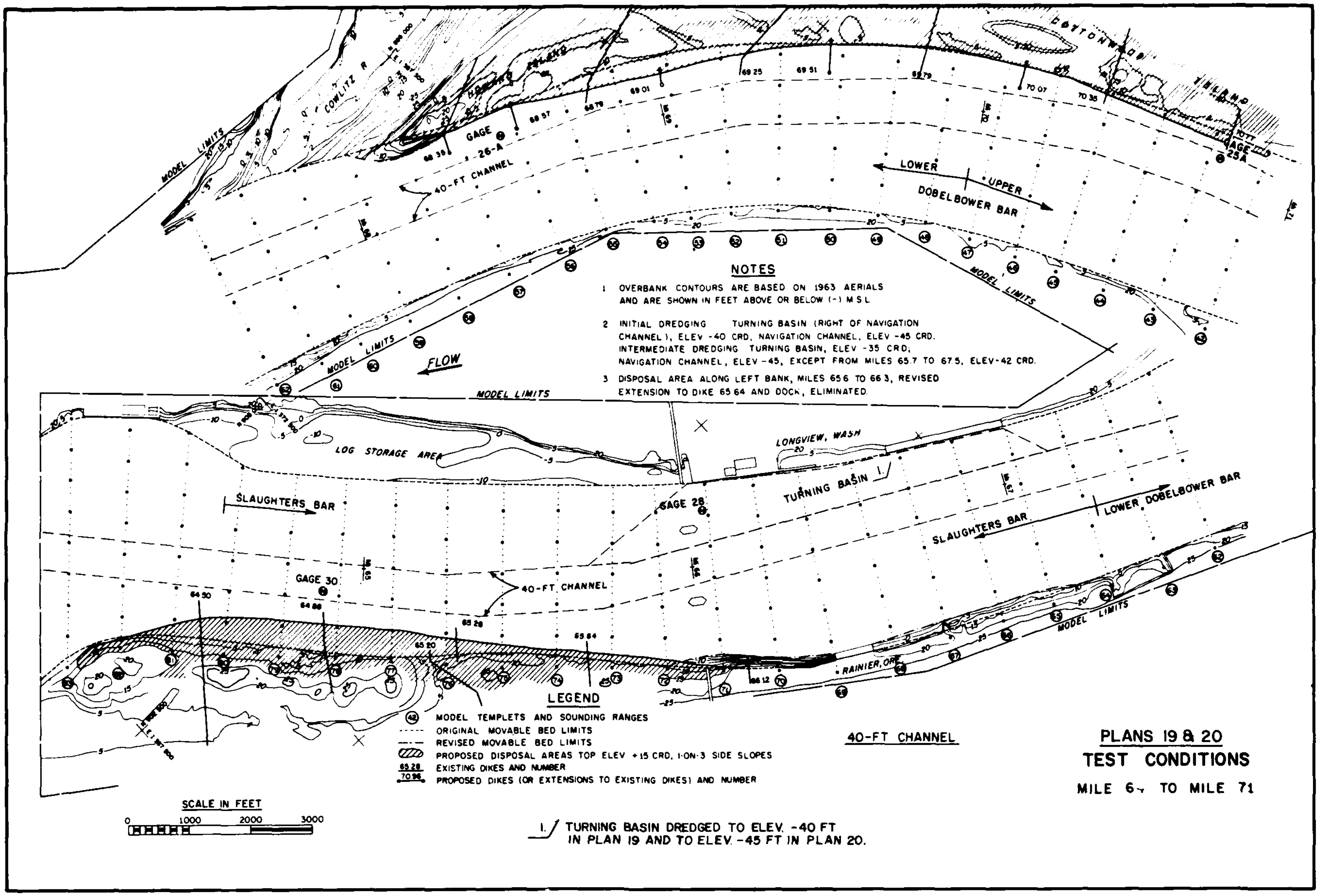
PER CENT CHANGE IN VELOCITIES

35-FT CHANNEL VS 40-FT CHANNEL

SLAUGHTERS BAR

RIVER MILES 66.22 AND 65.60

PLANS 13, 14, AND 15



PLANS 19 & 20
TEST CONDITIONS
MILE 6- TO MILE 71

NOTES

1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) MSL
2. INITIAL DREDGING TURNING BASIN (RIGHT OF NAVIGATION CHANNEL), ELEV -40 CRD, NAVIGATION CHANNEL, ELEV -45 CRD. INTERMEDIATE DREDGING TURNING BASIN, ELEV -35 CRD; NAVIGATION CHANNEL, ELEV -45, EXCEPT FROM MILES 65.7 TO 67.5, ELEV -42 CRD.
3. DISPOSAL AREA ALONG LEFT BANK, MILES 65.6 TO 66.3, REVISED EXTENSION TO DIKE 65.64 AND DOCK, ELIMINATED.

LEGEND

- MODEL TEMPLETS AND SOUNDING RANGES
- ORIGINAL MOVABLE BED LIMITS
- REVISED MOVABLE BED LIMITS
- PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
- EXISTING DIKES AND NUMBER
- PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER

1/ TURNING BASIN DREDGED TO ELEV. -40 FT IN PLAN 19 AND TO ELEV. -45 FT IN PLAN 20.

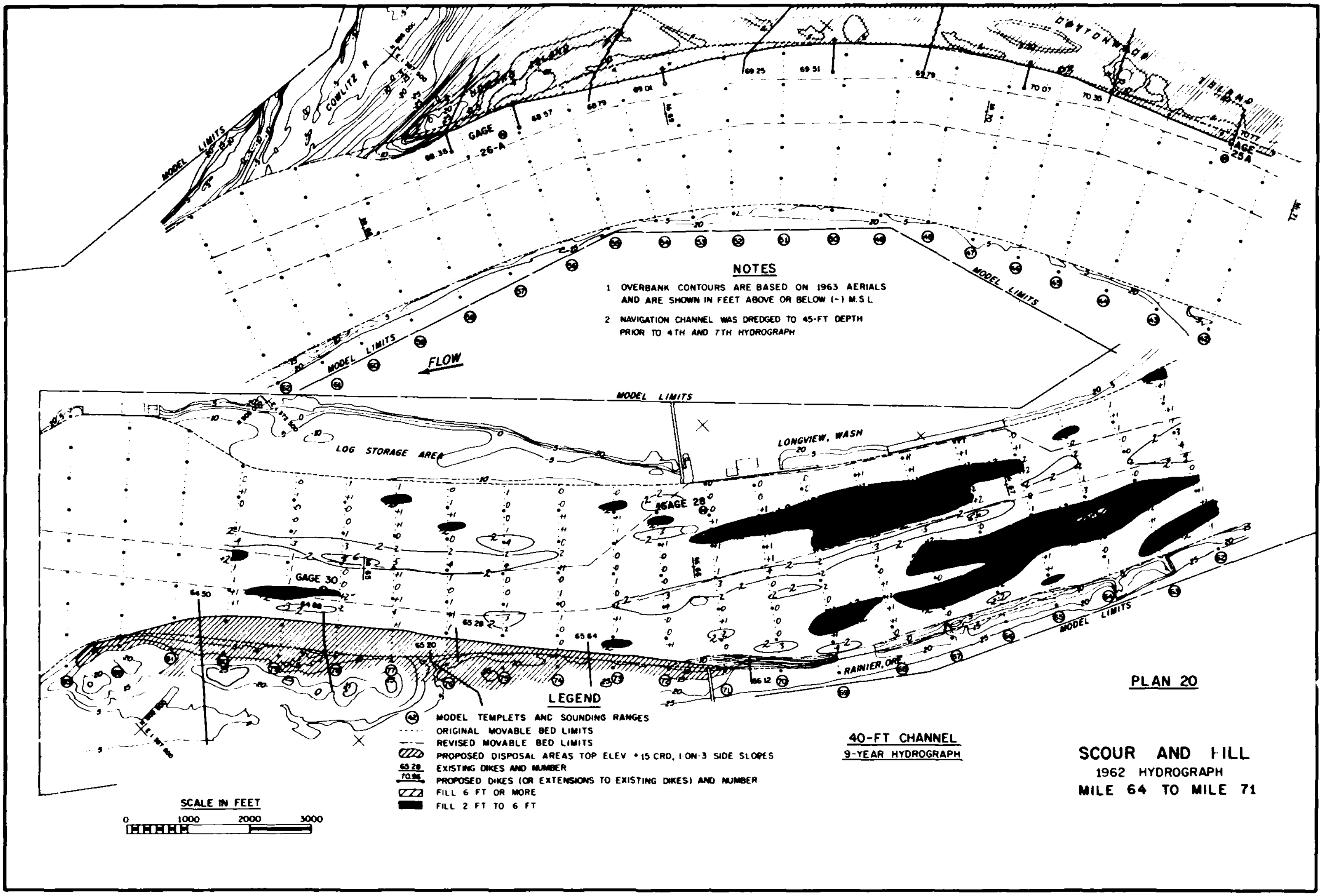
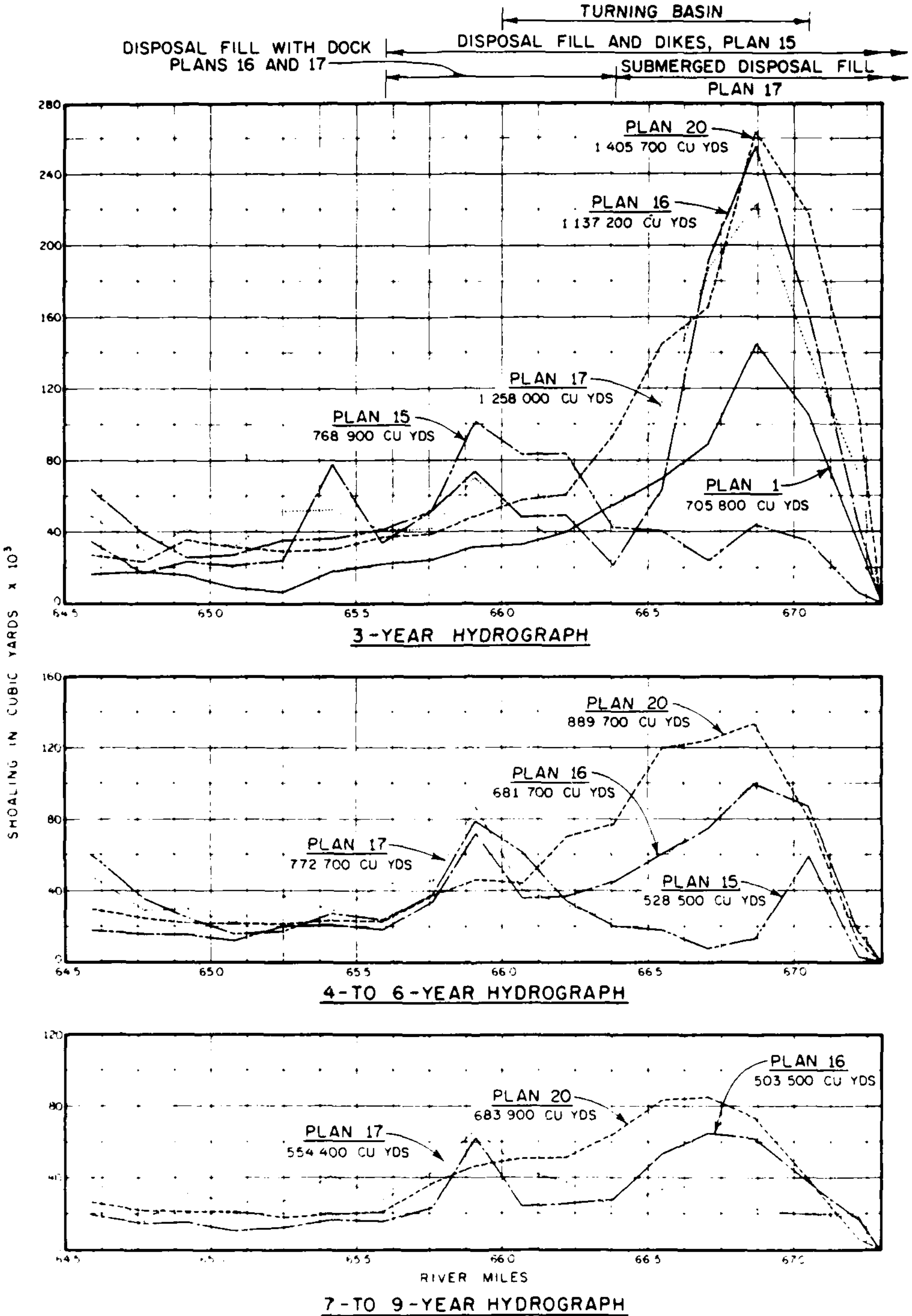

NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M.S.L.
2 NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPH
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
SCALE IN FEET
0 1000 2000 3000
40-FT CHANNEL
9-YEAR HYDROGRAPH
PLAN 20
SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71
FLOW
MODEL LIMITS
LOG STORAGE AREA
LONGVIEW, WASH
RAINIER, ORE
COWLITZ R
GAGE 26-A
GAGE 25A
GAGE 28
GAGE 30

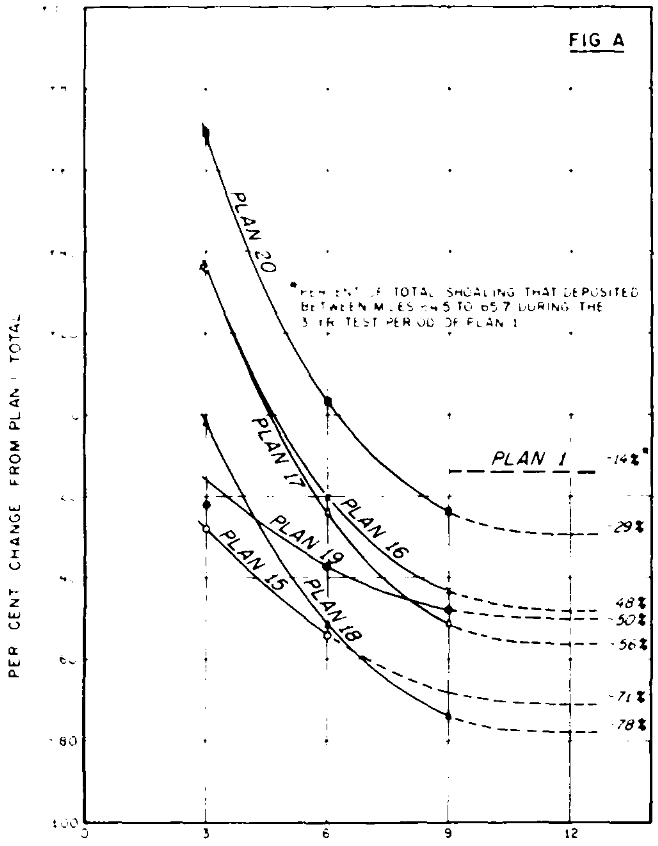
PLATE 102



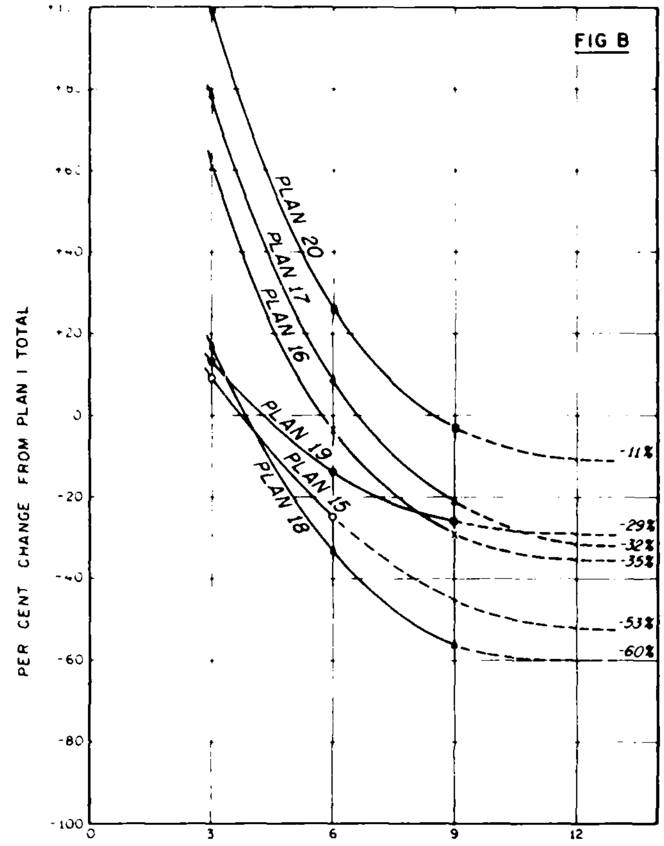
NOTES

1. NAVIGATION CHANNEL WAS DREDGED TO ELEV -45 CRD PRIOR TO 4TH AND 7TH HYDROGRAPHS
2. QUANTITIES ARE SHOALING IN THE NAVIGATION CHANNEL ABOVE ELEV -45 CRD (40 FT PLUS 5-FT OVERDEPTH).

SHOALING IN NAVIGATION CHANNEL
MILES 64.5 TO 67.3
PLANS 1, 15, 16, 17, AND 20



MILES 65.7 TO 67.3



MILES 64.5 TO 67.3

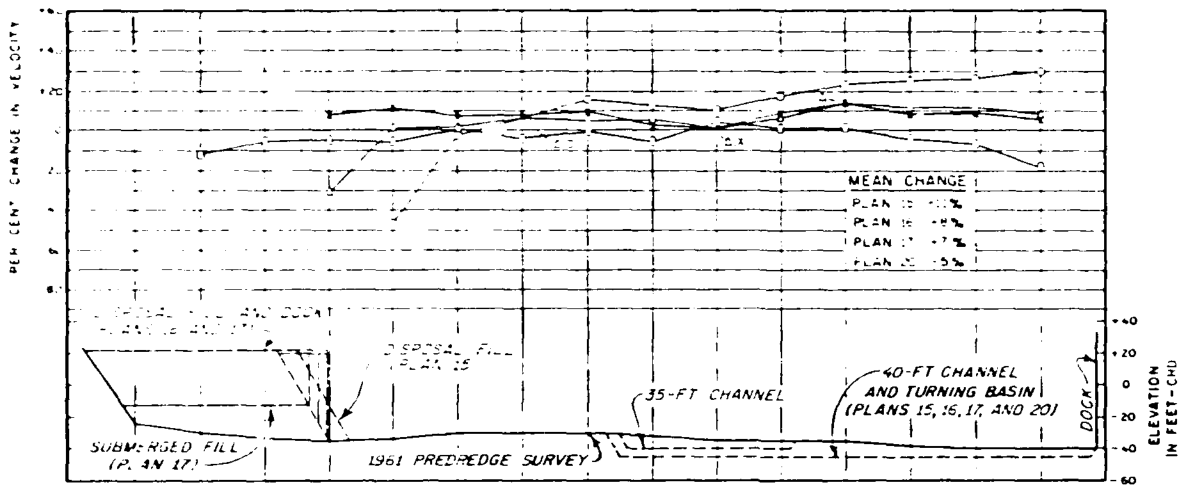
------ EXTRAPOLATION

NOTES

NAVIGATION CHANNEL WAS INITIALLY DREDGED TO ELEV -45 CRD. IN PLANS 18 AND 19, TURNING BASIN WAS DREDGED TO ELEV -40 CRD.

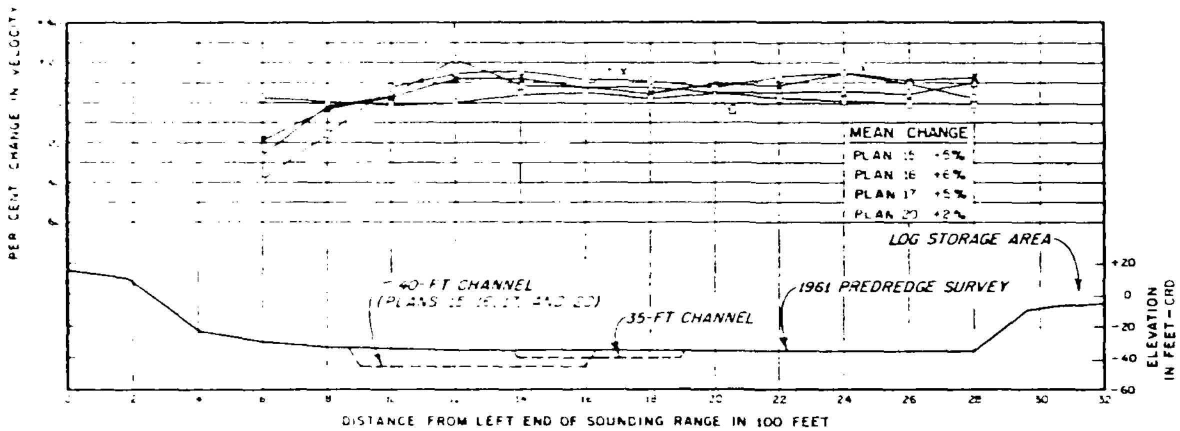
IN PLANS 18 AND 19, INTERMEDIATE DREDGING PRIOR TO 4TH AND 7TH HYDROGRAPH: NAVIGATION CHANNEL, ELEV -45 CRD, EXCEPT FROM MILES [illegible] ELEV -42 CRD; TURNING BASIN, ELEV -35 CRD.

OPTIMUM SHOALING REDUCTION
SLAUGHTERS BAR
PLANS 15 TO 20



RIVER MILE 66.22

SOUNDING RANGE 70



RIVER MILE 65.60

SOUNDING RANGE 74

NOTES

1. VELOCITIES WERE MEASURED AT 15-FT DEPTH
2. CHANGE IN VELOCITY IS SHOWN IN PER CENT OF 35-FT CHANNEL VELOCITIES
3. PERCENTAGES ARE AVERAGES OF SIMULATED FRESH WATER DISCHARGES OF 338 000 CFS AND 450 000 CFS

LEGEND

- PLAN 15
- PLAN 16
- PLAN 17
- PLAN 20

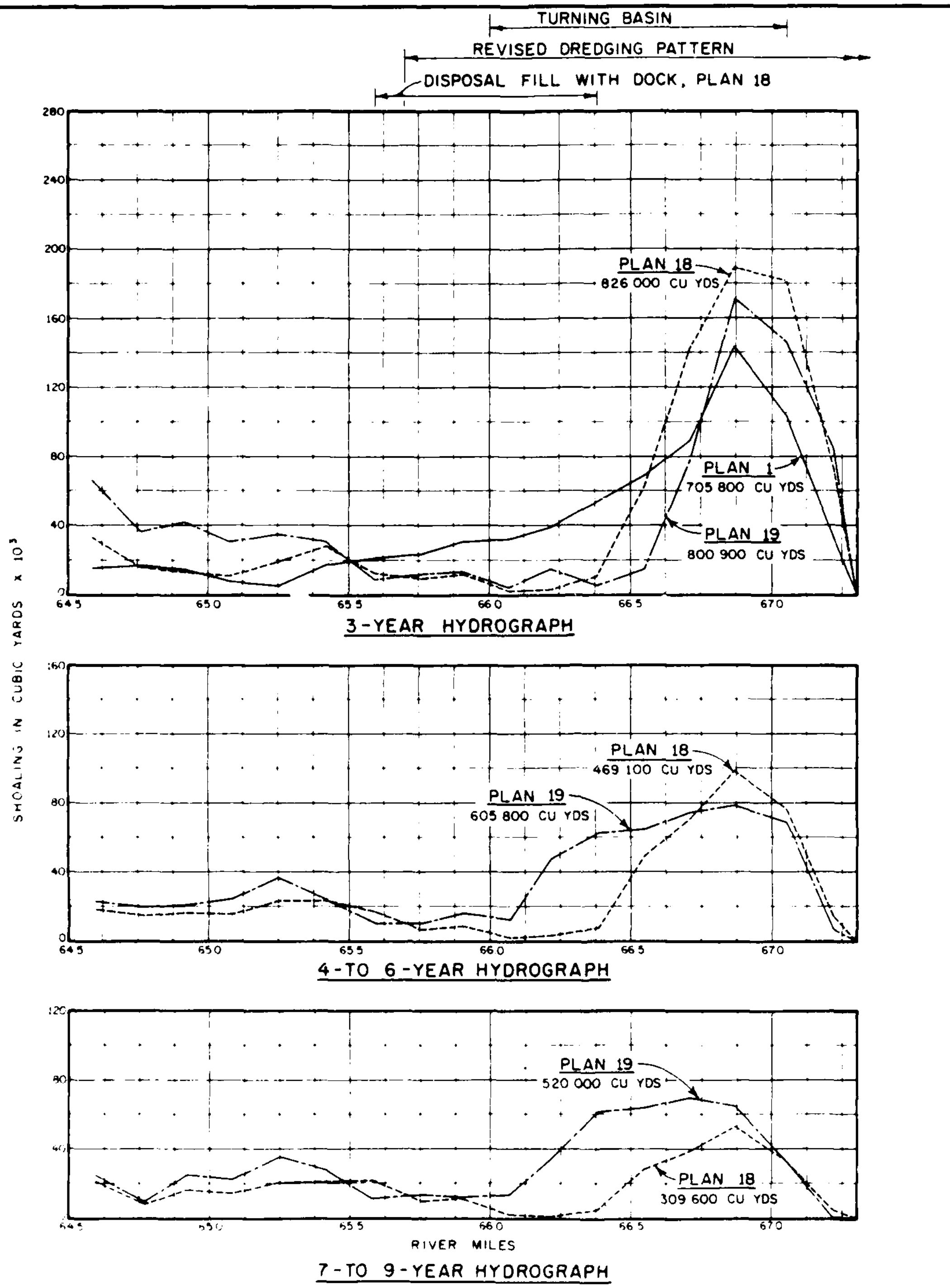
PER CENT CHANGE IN VELOCITIES

35-FT CHANNEL VS 40-FT CHANNEL

SLAUGHTERS BAR

MILES 66.22 AND 65.60

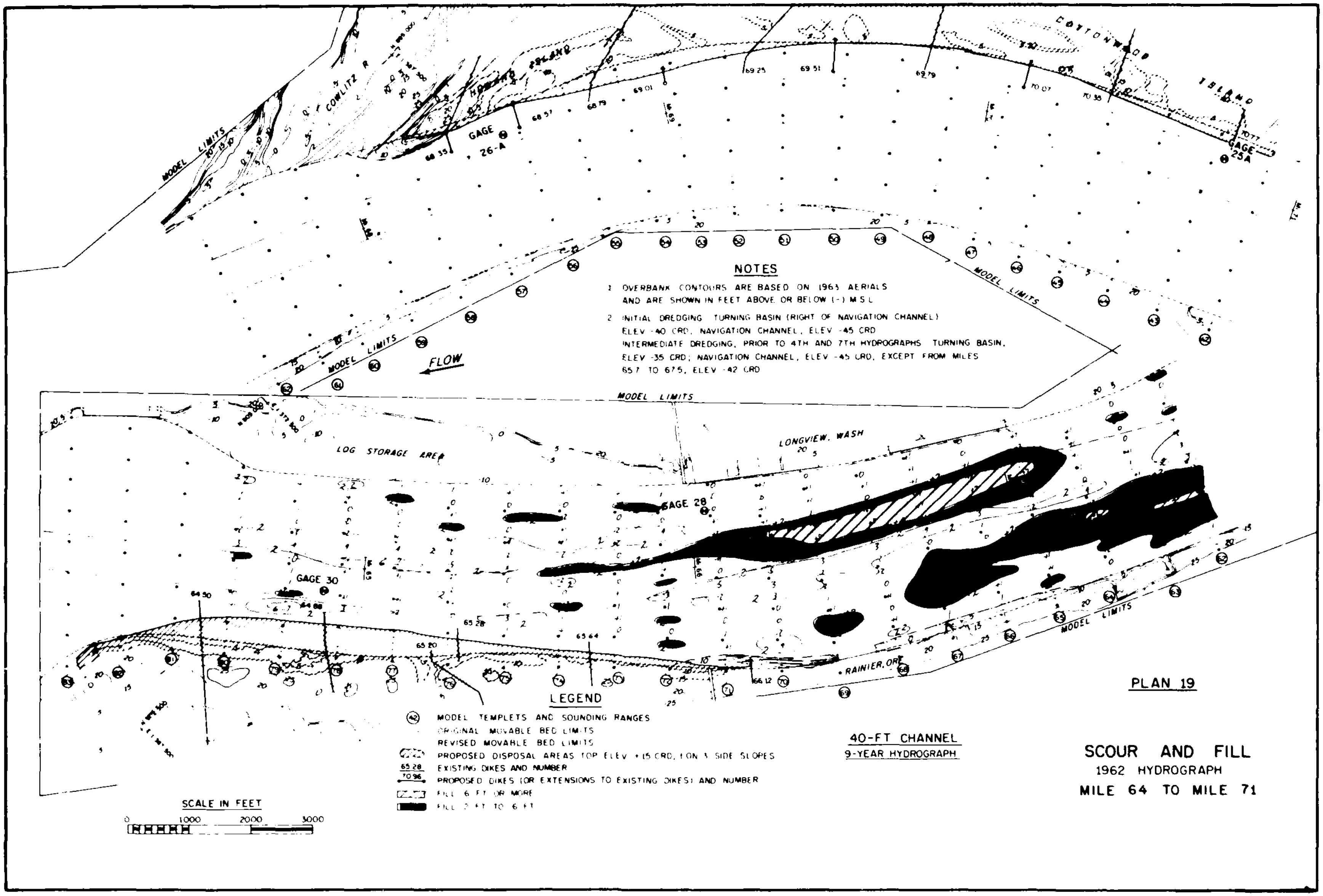
PLANS 15, 16, 17, AND 20



NOTES

1. NAVIGATION CHANNEL WAS INITIALLY DREDGED TO ELEV -45 CRD. IN PLANS 18 AND 19, TURNING BASIN WAS DREDGED TO ELEV -40 CRD.
2. IN PLANS 18 AND 19, INTERMEDIATE DREDGING PRIOR TO 4TH AND 7TH HYDROGRAPHS: NAVIGATION CHANNEL, ELEV -45 CRD, EXCEPT FROM MILES [illegible] TO [illegible], ELEV -42 CRD; TURNING BASIN, ELEV -35 CRD.
3. QUANTITIES FOR PLAN 1 ARE SHOALING IN THE NAVIGATION CHANNEL AND TURNING BASIN ABOVE ELEV -45 CRD. QUANTITIES FOR PLANS 18 AND 19 ARE ABOVE INTERMEDIATE DREDGING DEPTHS.

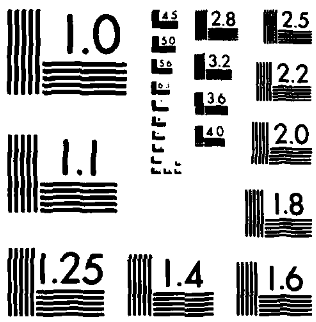
SHOALING IN NAVIGATION CHANNEL
MILES 645 TO 673
PLANS 1, 18, AND 19


NOTES
1. OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M.S.L.
2. INITIAL DREDGING: TURNING BASIN (RIGHT OF NAVIGATION CHANNEL) ELEV -40 CRD; NAVIGATION CHANNEL, ELEV -45 CRD
INTERMEDIATE DREDGING, PRIOR TO 4TH AND 7TH HYDROGRAPHS: TURNING BASIN, ELEV -35 CRD; NAVIGATION CHANNEL, ELEV -45 CRD, EXCEPT FROM MILES 65.7 TO 67.5, ELEV -42 CRD
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1 ON 3 SIDE SLOPES
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
SCALE IN FEET
0
1000
2000
3000
MODEL LIMITS
FLOW
COWLITZ R
HOWARD ISLAND
COTTONWOOD ISLAND
GAGE 26-A
GAGE 25A
GAGE 28
GAGE 30
LOG STORAGE AREA
LONGVIEW, WASH
RAINIER, ORE
40-FT CHANNEL
9-YEAR HYDROGRAPH
PLAN 19
SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71

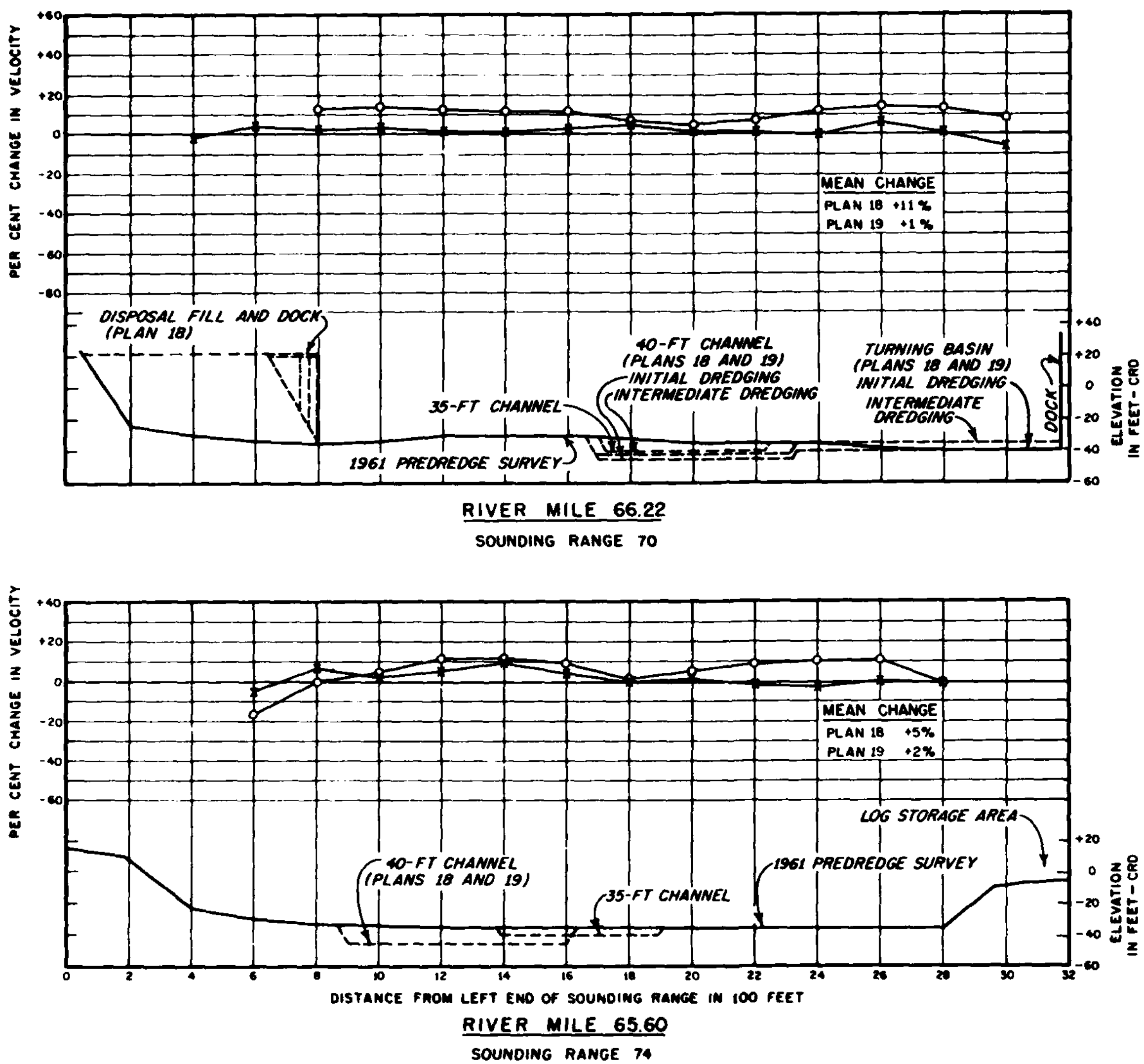
AD-A149 374 NAVIGATION CHANNEL IMPROVEMENT COLUMBIA RIVER OREGON AND WASHINGTON - LON..(U) ARMY ENGINEER DIV NORTH PACIFIC BONNEVILLE OR DIV HYDRAULIC L.. SEP 84 3/3

UNCLASSIFIED TR-118-1 F/G 13/2 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



NOTES

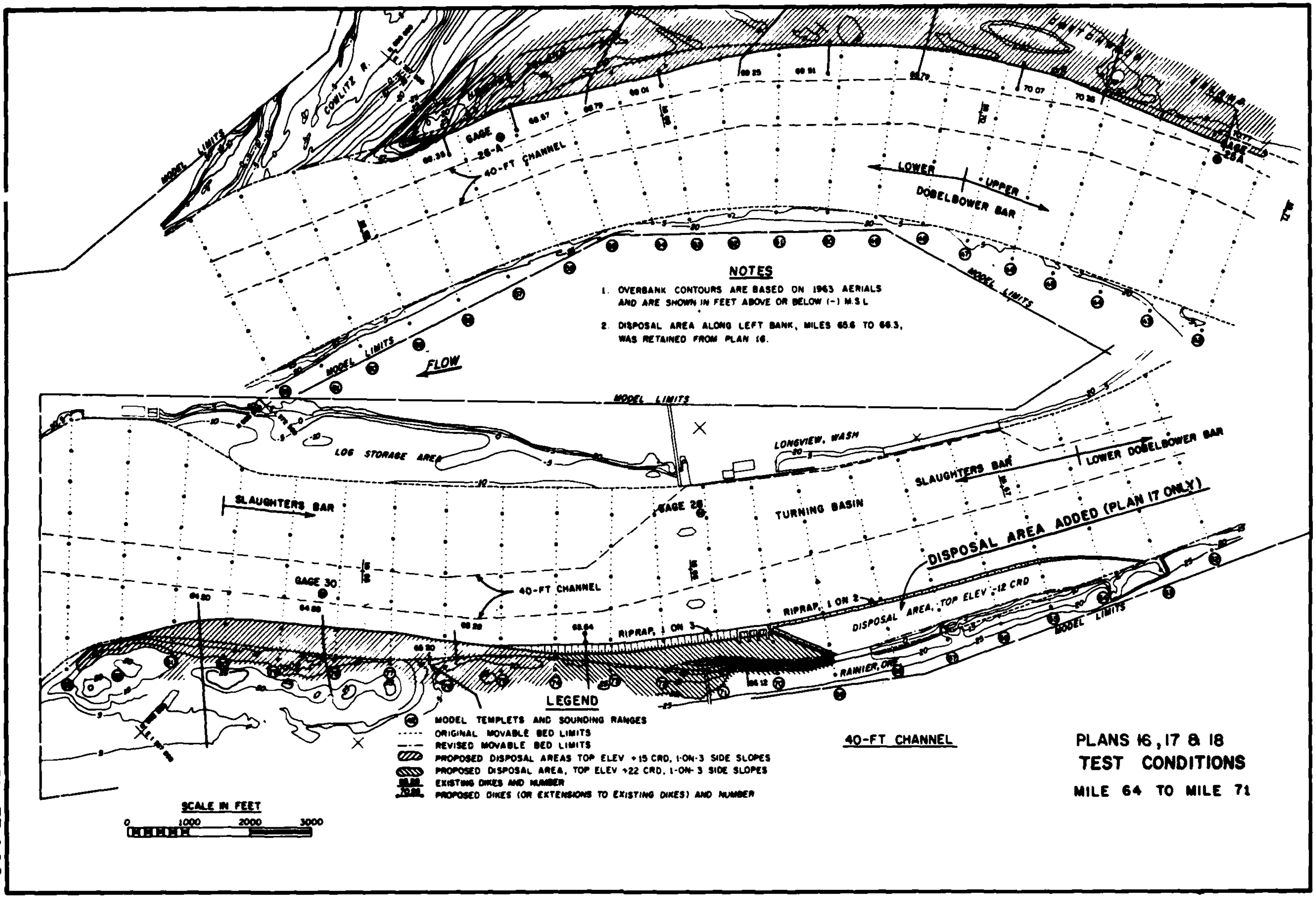
1. VELOCITIES WERE MEASURED AT 15-FT DEPTH.
2. CHANGE IN VELOCITY IS SHOWN IN PER CENT OF 35-FT CHANNEL VELOCITIES.
3. PERCENTAGES ARE AVERAGES OF SIMULATED FRESH WATER DISCHARGES OF 338 000 CFS AND 450 000 CFS.

LEGEND

PLAN 18

PLAN 19

PER CENT CHANGE IN VELOCITIES
35-FT CHANNEL VS 40-FT CHANNEL
SLAUGHTERS BAR
RIVER MILES 66.22 AND 65.60
PLANS 18 AND 19



PLANS 16, 17 & 18
TEST CONDITIONS
MILE 64 TO MILE 71

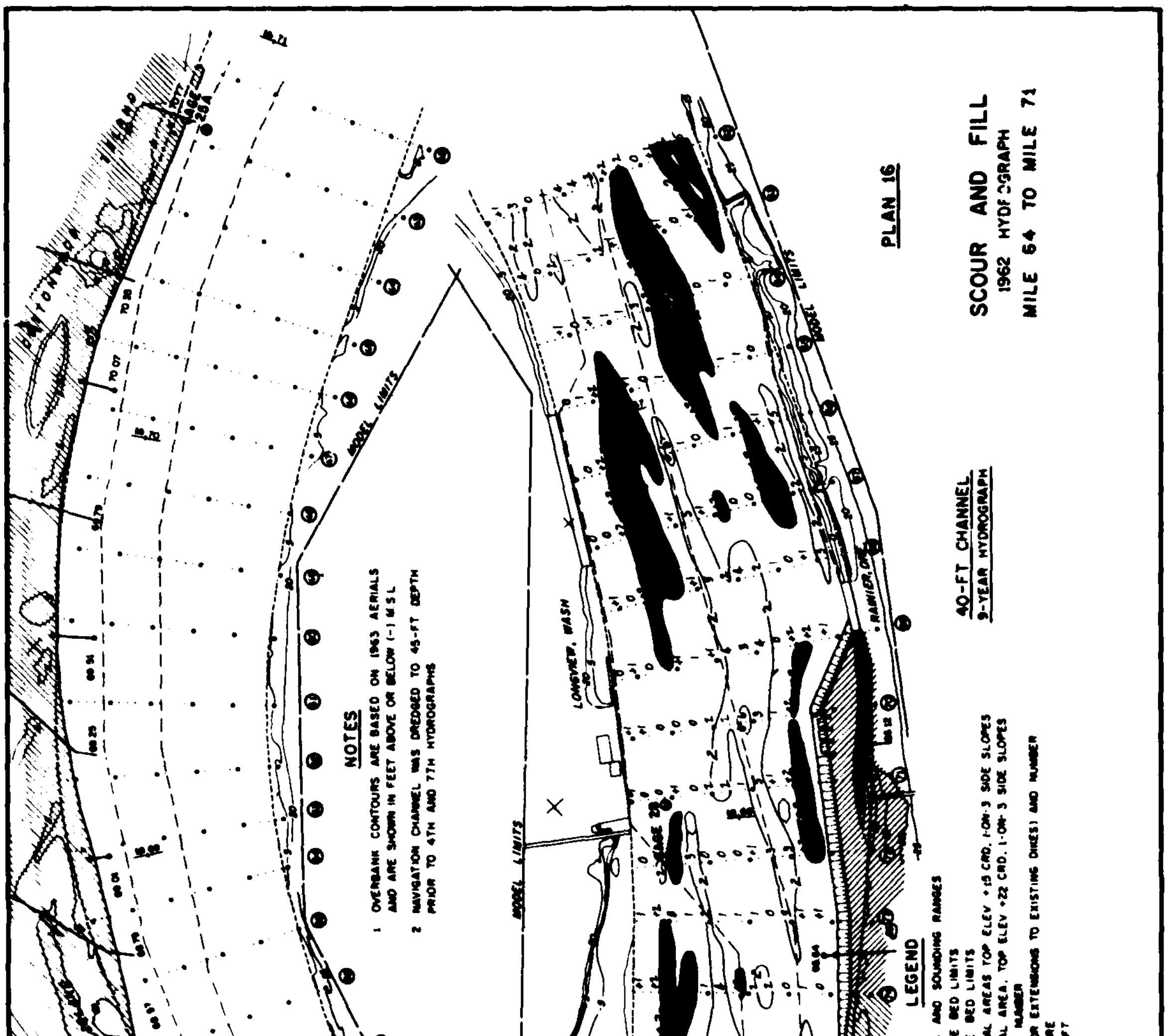
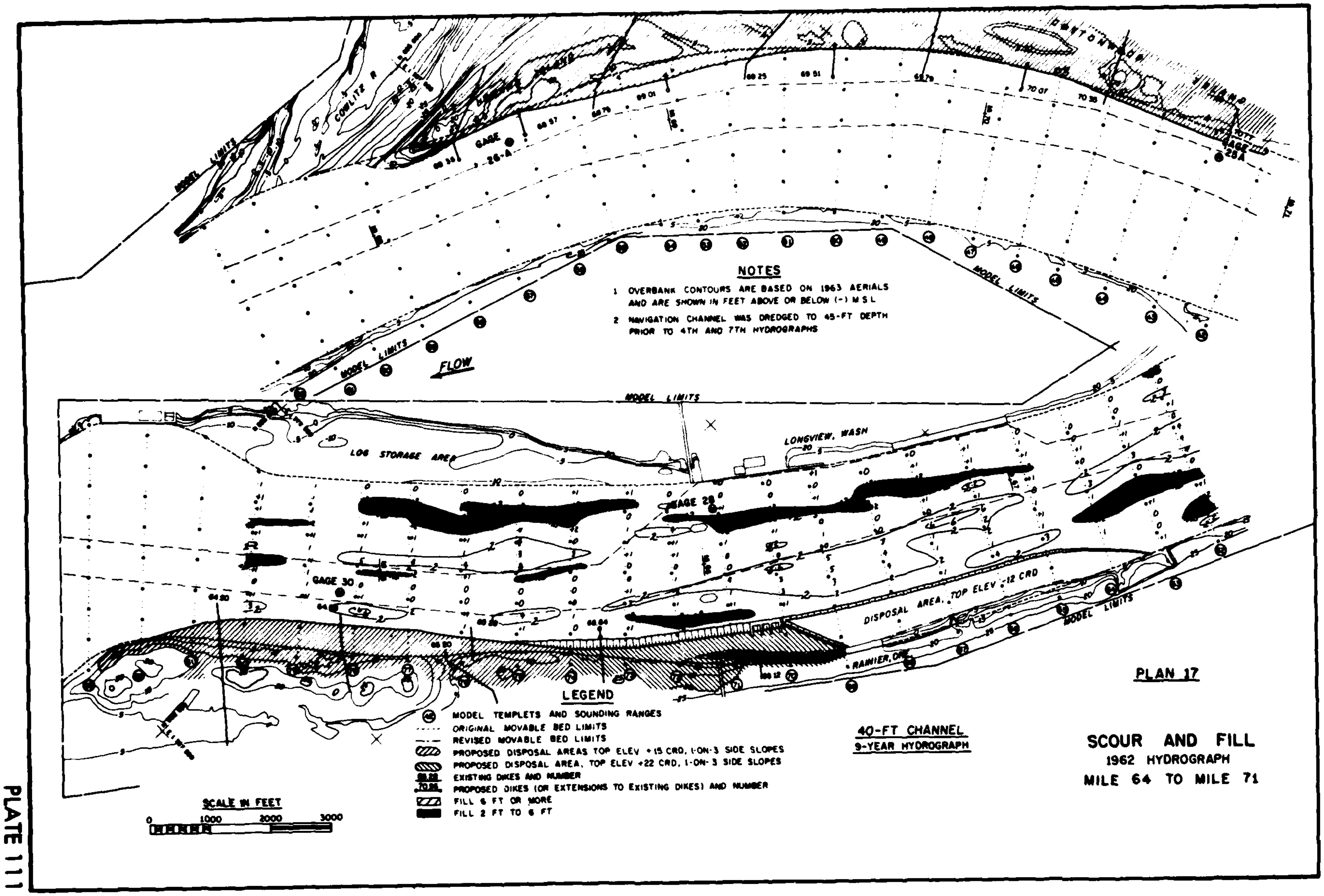

PLAN 16
SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71
40-FT CHANNEL
9-YEAR HYDROGRAPH
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2 NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DISPOSAL AREA, TOP ELEV +22 CRD, 1-ON-3 SIDE SLOPES
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
SCALE IN FEET
0 1000 2000 3000
FLOW
MODEL LIMITS
LOG STORAGE AREA
LONGVIEW WASH
RAINIER, ORE

PLATE 110


NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2 NAVIGATION CHANNEL WAS DREDGED TO 45-FT DEPTH PRIOR TO 4TH AND 7TH HYDROGRAPHS
FLOW
MODEL LIMITS
COWLITZ R
GAGE 26-A
GAGE 28A
GAGE 28
GAGE 30
LONGVIEW, WASH
LOG STORAGE AREA
DISPOSAL AREA, TOP ELEV -12 CRD
RAINIER, ORE
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DISPOSAL AREA, TOP ELEV +22 CRD, 1-ON-3 SIDE SLOPES
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
SCALE IN FEET
0 1000 2000 3000
40-FT CHANNEL
9-YEAR HYDROGRAPH
PLAN 17
SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71

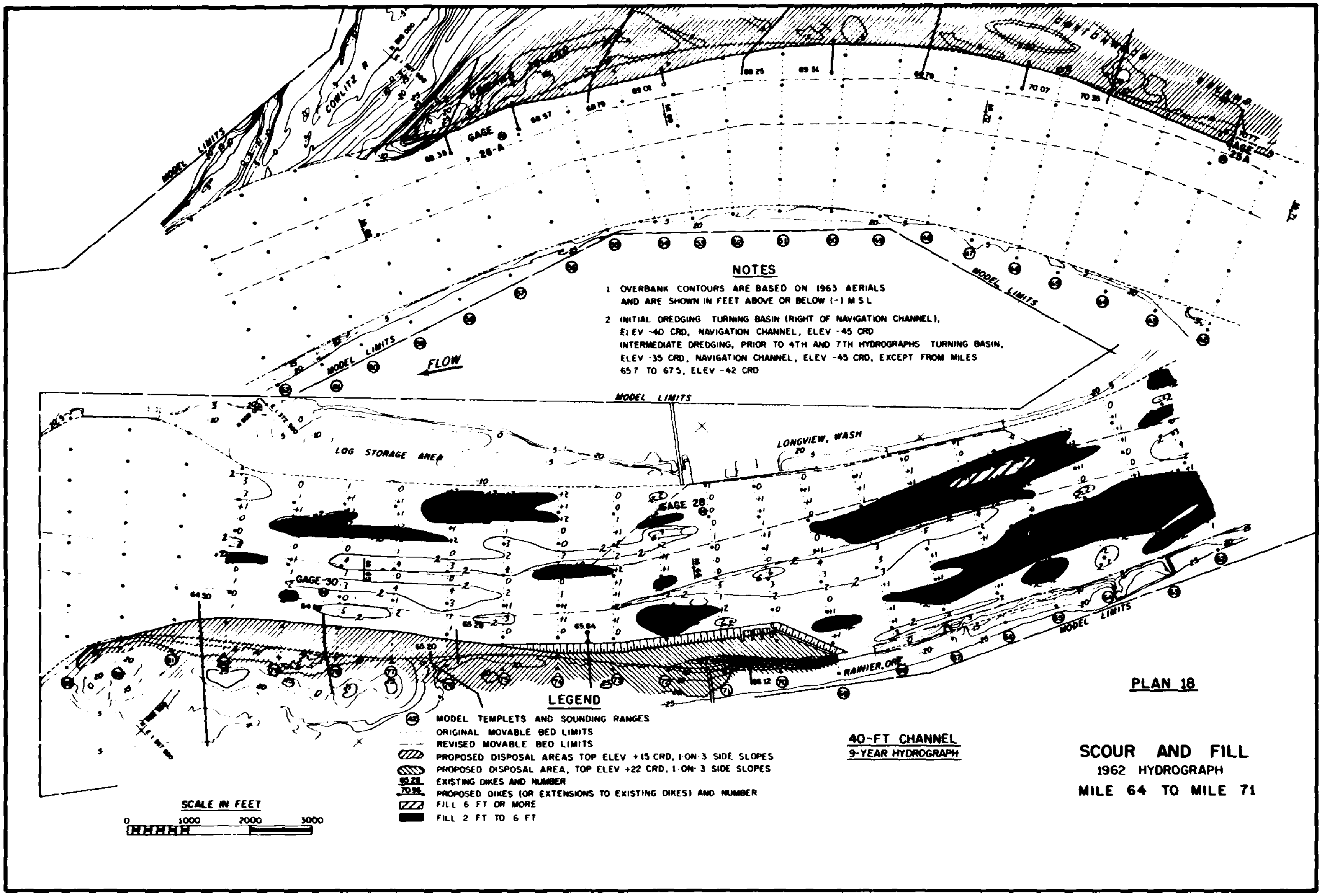

MODEL LIMITS
COWLITZ R
GAGE 26-A
GAGE 25A
FLOW
NOTES
1 OVERBANK CONTOURS ARE BASED ON 1963 AERIALS AND ARE SHOWN IN FEET ABOVE OR BELOW (-) M S L
2 INITIAL DREDGING TURNING BASIN (RIGHT OF NAVIGATION CHANNEL), ELEV -40 CRD, NAVIGATION CHANNEL, ELEV -45 CRD
INTERMEDIATE DREDGING, PRIOR TO 4TH AND 7TH HYDROGRAPHS TURNING BASIN, ELEV -35 CRD, NAVIGATION CHANNEL, ELEV -45 CRD, EXCEPT FROM MILES 65.7 TO 67.5, ELEV -42 CRD
LOG STORAGE AREA
LONGVIEW, WASH
GAGE 28
GAGE 30
RAINIER, ORE
LEGEND
MODEL TEMPLETS AND SOUNDING RANGES
ORIGINAL MOVABLE BED LIMITS
REVISED MOVABLE BED LIMITS
PROPOSED DISPOSAL AREAS TOP ELEV +15 CRD, 1-ON-3 SIDE SLOPES
PROPOSED DISPOSAL AREA, TOP ELEV +22 CRD, 1-ON-3 SIDE SLOPES
EXISTING DIKES AND NUMBER
PROPOSED DIKES (OR EXTENSIONS TO EXISTING DIKES) AND NUMBER
FILL 6 FT OR MORE
FILL 2 FT TO 6 FT
SCALE IN FEET
0 1000 2000 3000
40-FT CHANNEL
9-YEAR HYDROGRAPH
PLAN 18
SCOUR AND FILL
1962 HYDROGRAPH
MILE 64 TO MILE 71

PLATE 112

END

FILMED

2-85

DTIC